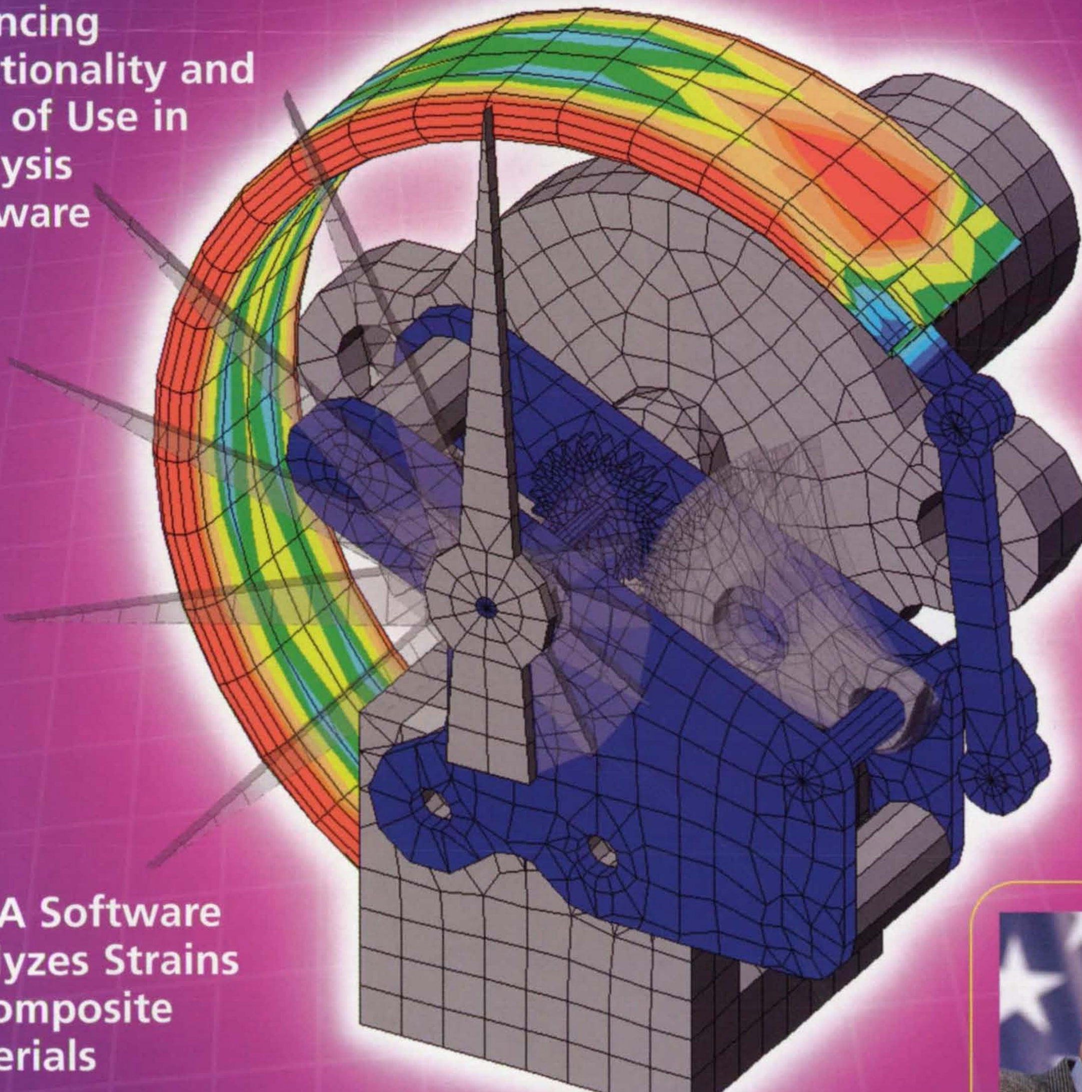
November 2002 www.nasatech.com Vol. 26 No. 11

TECH BRIEFS

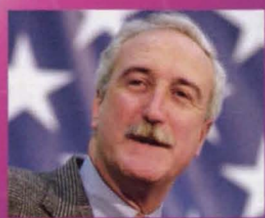
ENGINEERING SOLUTIONS FOR DESIGN & MANUFACTURING



Balancing Functionality and Ease of Use in Analysis Software

NASA Software Analyzes Strains in Composite Materials

Photonics Tech Briefs



An Interview With NASA Administrator Sean O'Keefe

Page 18

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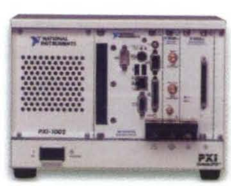

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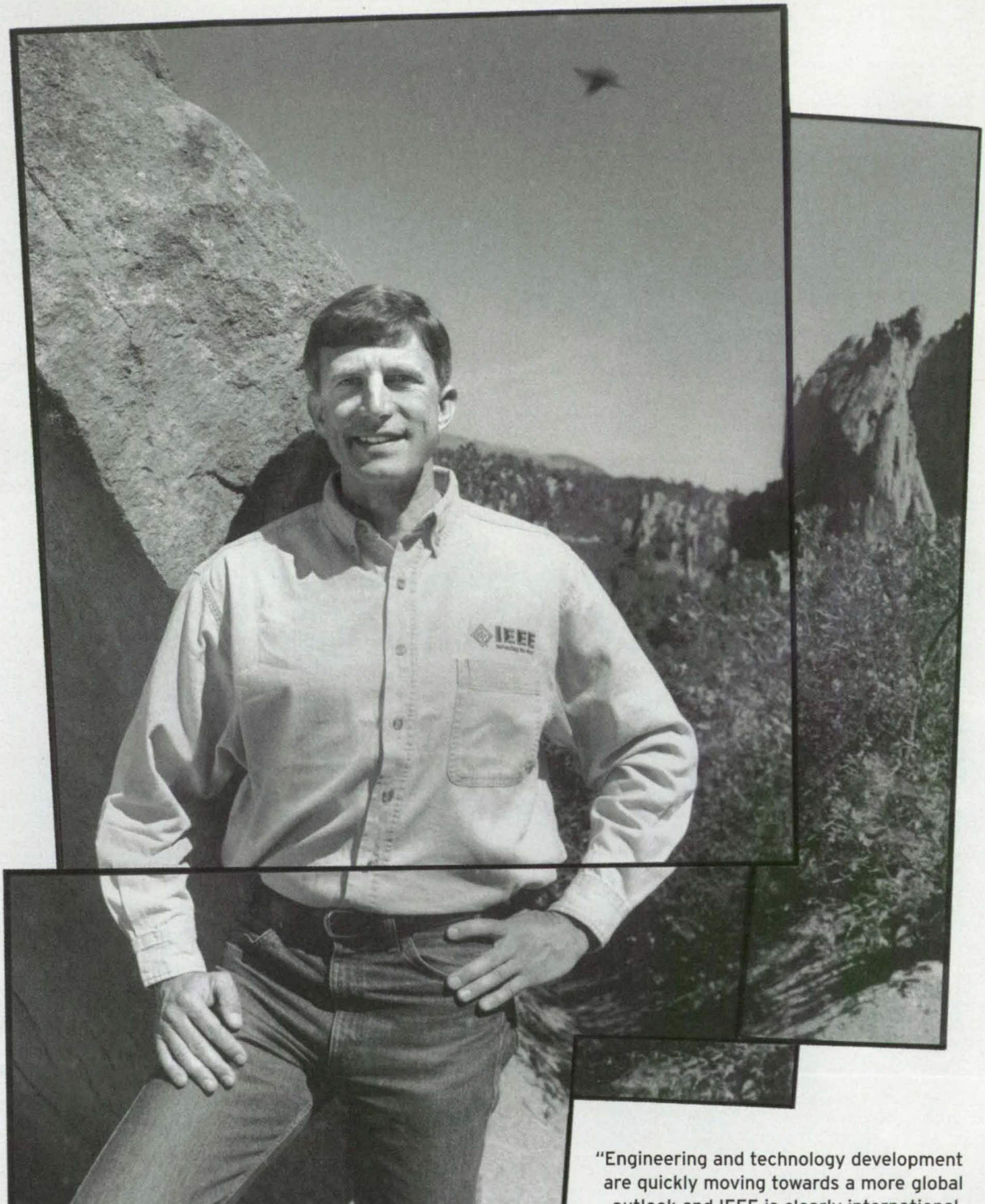

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TECH BRIEFS

ENGINEERING SOLUTIONS FOR DESIGN & MANUFACTURING

FEATURES

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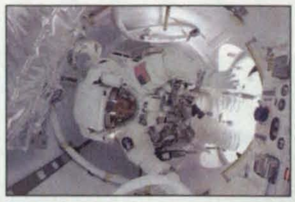

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SOLUTIONS

DEPARTMENTS

NEW FOR DESIGN ENGINEERS

SPECIAL SUPPLEMENT

Follows page 42 in selected editions only.

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Pittsburgh, PA 15238-2932 USA
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Fax 1.412.967.2781
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verifydesign.ALGOR.com
United Kingdom 0.800.731.0399
Singapore 800.120.3775
France 0.800.918.917
Italy 800.783.132

FEA Software Chosen to Verify Wheel Design for Goodyear "Run-Flat" Tires

The Effect of Low Inflation Pressure on Tire Wheel

The Goodyear Tire & Rubber Company developed a run-flat tire called an extended mobility technology (EMT) tire that can be safely driven without air for at least 80 km (50 miles). Before these new tires could be used, Goodyear needed to verify that existing wheel designs would support this new technology. Goodyear EMT tires are now original equipment on the Chevrolet Corvette, Daimler Chrysler Prowler and the Mini from BMW Group.

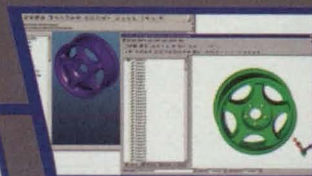
The Challenge

Goodyear needed to make certain that the wheel design could handle the low pressure caused by an under-inflated tire. The final design needed to maintain the safety benefit of controlled handling and braking.

The Solution

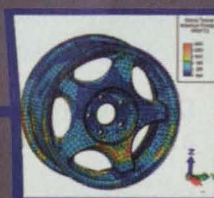
While a Ph.D. candidate at the University of Akron, John Stearns performed a parametric study of inflation pressure and stresses in a standard wheel. A typical aluminum wheel was modeled in Pro/ENGINEER and the geometry was captured with ALGOR. Constraints were applied to represent the wheel's attachment to a vehicle and a combination of pressure loads were applied to simulate vehicle weight and inflation pressures of 0, 17 and 35 psi. Higher stresses were found at lower inflation pressures, but the magnitude of the stresses was low enough that a standard wheel could be recommended for EMT tires. Over one million run-flat EMT tires are now being used on the road.

"I chose ALGOR for this project because InCAD technology offers better control over CAD geometry and flexible meshing capabilities."
-John Stearns, Ph.D.



The wheel geometry was modeled in Pro/ENGINEER and captured using InCAD technology.

A non-uniform pressure load of 296 psi at 0 degrees to 0 psi at 40 degrees was applied to simulate the vehicle weight.



Maximum principal stress results revealed that the wheel experienced greater stress at lower inflation pressures.

Laboratory test results correlated well with ALGOR's FEA results.

Solutions for More Efficient Design

Engineers around the world choose ALGOR because of its CAD support, flexible finite element modeling capabilities and wide range of FEA-based simulation capabilities. Simulation capabilities include Mechanical Event Simulation for FEA-based motion and stress analysis, full multiphysics and stress, linear dynamic, heat transfer, fluid flow, electrostatic and piping. These capabilities enable engineers in industries such as automotive, aerospace, medical, consumer products, military, electric power, petroleum, manufacturing, micro electro mechanical systems (MEMS) and more to accelerate time to market and make better, safer products at a lower cost.

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PRODUCT OF THE MONTH

SolidWorks 2003 3D CAD software from SolidWorks Corp., Concord, MA, includes new modeling features, built-in analysis, an on-line supplier resource, and physical simulation capabilities.

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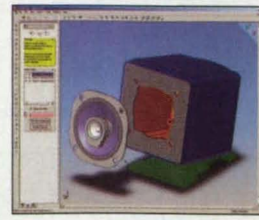
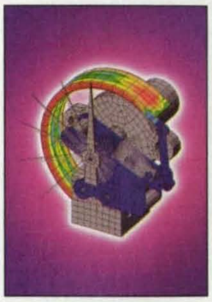
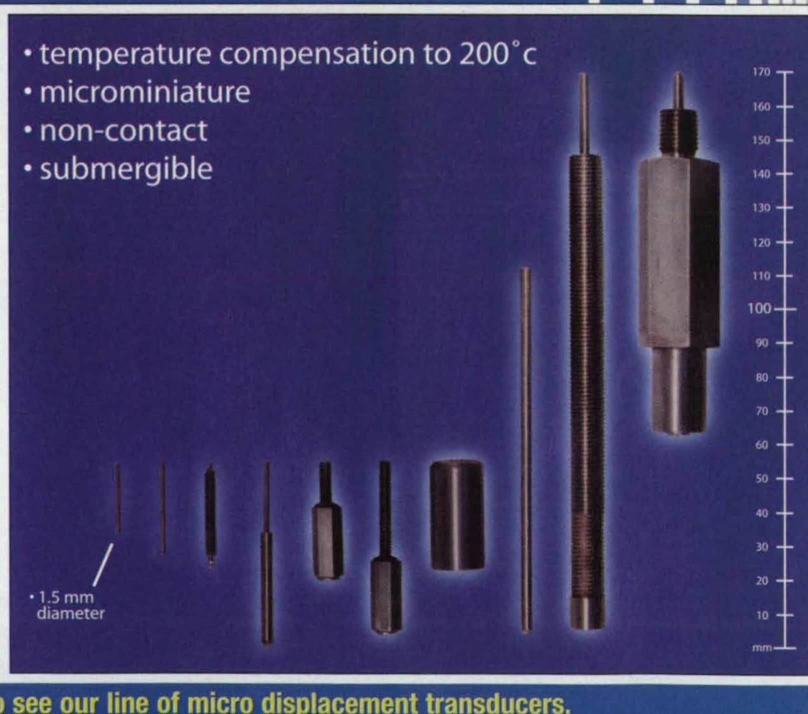


ON THE COVER



This Mechanical Event Simulation (MES) of a Bourdon tube pressure gauge was performed using MES software from ALGOR, Inc., Pittsburgh, PA. The model utilizes kinematic elements and surface-to-surface contact elements between the gauge's gears to replicate the motion of the indicator needle as pressure is increased within the tube. We asked ALGOR and other leading vendors in the analysis and simulation software field what the next market trends will be. Find out where they see the industry heading in the feature beginning on page 24.

(Image courtesy of ALGOR, Inc.)

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NASA Commercial Technology Team

NASA's R&D efforts produce a robust supply of promising technologies with applications in many industries. A key mechanism in identifying commercial applications for this technology is NASA's national network of commercial technology organizations. The network includes ten NASA field centers, six Regional Technology Transfer Centers (RTTCs), the National Technology Transfer Center (NTTC), business support organizations, and a full tie-in with the Federal Laboratory Consortium (FLC) for Technology Transfer. Call (609) 667-7737 for the FLC coordinator in your area.

NASA's Technology Sources

If you need further information about new technologies presented in *NASA Tech Briefs*, request the Technical Support Package (TSP) indicated at the end of the brief. If a TSP is not available, the Commercial Technology Office at the NASA field center that sponsored the research can provide you with additional information and, if applicable, refer you to the innovator(s). These centers are the source of all NASA-developed technology.

Ames Research Center
Selected technological strengths: Information Technology; Biotechnology; Nanotechnology; Aerospace Operations Systems; Rotorcraft; Thermal Protection Systems.
Carolina Blake
(650) 604-1754
cblake@mail.arc.nasa.gov

Dryden Flight Research Center
Selected technological strengths: Aerodynamics; Aeronautics Flight Testing; Aeropropulsion; Flight Systems; Thermal Testing; Integrated Systems Test and Validation.
Jenny Baer-Riedhart
(661) 276-3689
jenny.baer-riedhart@dfrc.nasa.gov

Goddard Space Flight Center
Selected technological strengths: Earth and Planetary Science Missions; LIDAR; Cryogenic Systems; Tracking; Telemetry; Remote Sensing; Command.
Nona Cheeks
(301) 286-5810
Nona.K.Cheeks.1@gsfc.nasa.gov

Jet Propulsion Laboratory
Selected technological strengths: Near/Deep-Space Mission Engineering; Microspacecraft; Space Communications; Information Systems; Remote Sensing; Robotics.
Merle McKenzie
(818) 354-2577
merle.mckenzie@jpl.nasa.gov

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Selected technological strengths: Artificial Intelligence and Human Computer Interface; Life Sciences; Human Space Flight Operations; Avionics; Sensors; Communications.
Charlene E. Gilbert
(281) 483-3809
commercialization@jsc.nasa.gov

Kennedy Space Center
Selected technological strengths: Fluids and Fluid Systems; Materials Evaluation; Process Engineering; Command, Control and Monitor Systems; Range Systems; Environmental Engineering and Management.
Jim Aliberti
(321) 867-6224
Jim.Aliberti-1@ksc.nasa.gov

Langley Research Center
Selected technological strengths: Aerodynamics; Flight Systems; Materials; Structures; Sensors; Measurements; Information Sciences.
Sam Morello
(757) 864-6005
s.a.morello@larc.nasa.gov

John H. Glenn Research Center at Lewis Field
Selected technological strengths: Aeropropulsion; Communications; Energy Technology; High Temperature Materials Research.
Larry Viterna
(216) 433-3484
cto@grc.nasa.gov

Marshall Space Flight Center
Selected technological strengths: Materials; Manufacturing; Nondestructive Evaluation; Biotechnology; Space Propulsion; Controls and Dynamics; Structures; Microgravity Processing.
Vernotto McMillan
(256) 544-2615
vernotto.mcmillan@msfc.nasa.gov

Stennis Space Center
Selected technological strengths: Propulsion Systems; Test/Monitoring; Remote Sensing; Nonintrusive Instrumentation.
Kirk Sharp
(228) 688-1929
kirk.sharp@ssc.nasa.gov

NASA-Sponsored Commercial Technology Organizations

These organizations were established to provide rapid access to NASA and other federal R&D and foster collaboration between public and private sector organizations. They also can direct you to the appropriate point of contact within the Federal Laboratory Consortium. To reach the Regional Technology Transfer Center nearest you, call (800) 472-6785.

Joseph Allen
National Technology Transfer Center
(800) 678-6882

Ken Dozier
Far-West Technology Transfer Center
University of Southern California
(213) 743-2353

James P. Dunn
Center for Technology Commercialization
Westborough, MA
(508) 870-0042

B. David Bridges
Southeast Technology Transfer Center
Georgia Institute of Technology
(404) 894-6786

Gary Sera
Mid-Continent Technology Transfer Center
Texas A&M University
(409) 845-8762

Charles Blankenship
Technology Commercialization Center
Newport News, VA
(757) 269-0025

Pierrette Woodford
Great Lakes Industrial Technology Transfer Center
Battelle Memorial Institute
(216) 898-6400

NASA ON-LINE: Go to NASA's Commercial Technology Network (CTN) on the World Wide Web at **http://nctn.hq.nasa.gov** to search NASA technology resources, find commercialization opportunities, and learn about NASA's national network of programs, organizations, and services dedicated to technology transfer and commercialization.

NASA Program Offices

At NASA Headquarters there are seven major program offices that develop and oversee technology projects of potential interest to industry. The street address for these strategic business units is: NASA Headquarters, 300 E St. SW, Washington, DC 20546.

Carl Ray
Small Business Innovation Research Program (SBIR) & Small Business Technology Transfer Program (STTR)
(202) 358-4652
cray@mail.hq.nasa.gov

Dr. Robert Norwood
Office of Commercial Technology (Code RW)
(202) 358-2320
rnorwood@mail.hq.nasa.gov

John Mankins
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(202) 358-4659
jmankins@mail.hq.nasa.gov

Terry Hertz
Office of Aero-Space Technology (Code RS)
(202) 358-4636
thertz@mail.hq.nasa.gov

Glen Mucklow
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(202) 358-2235
gmucklow@mail.hq.nasa.gov

Roger Crouch
Office of Microgravity Science Applications (Code U)
(202) 358-0689
rcrouch@hq.nasa.gov

Granville Paules
Office of Mission to Planet Earth (Code Y)
(202) 358-0706
gpaules@mtpe.hq.nasa.gov

NASA's Business Facilitators

NASA has established several organizations whose objectives are to establish joint sponsored research agreements and incubate small start-up companies with significant business promise.

Wayne P. Zeman
Lewis Incubator for Technology
Cleveland, OH
(440) 260-3300

B. Greg Hinkebein
Mississippi Enterprise for Technology
Stennis Space Center, MS
(800) 746-4699

Julie Holland
NASA Commercialization Center
Pomona, CA
(909) 869-4477

Bridgette Smalley
UH-NASA Technology Commercialization Incubator
Houston, TX
(713) 743-9155

John Fini
Goddard Space Flight Center Incubator
Baltimore, MD
(410) 327-9150 x1034

Thomas G. Rainey
NASA KSC Business Incubation Center
Titusville, FL
(407) 383-5200

Joanne W. Randolph
BizTech
Huntsville, AL
(256) 704-6000

Joe Becker
Ames Technology Commercialization Center
San Jose, CA
(408) 557-6700

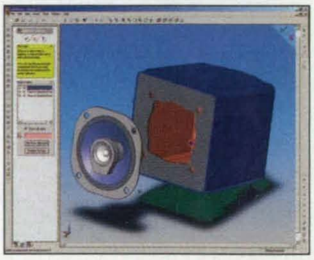
Marty Kaszubowski
Hampton Roads Technology Incubator (Langley Research Center)
Hampton, VA
(757) 865-2140

Paul Myrda
NASA Illinois Commercialization Center
West Chicago, IL
(630) 845-6510

If you are interested in information, applications, and services relating to satellite and aerial data for Earth resources, contact: Dr. Stan Morain, **Earth Analysis Center,** (505) 277-3622.

UpFront

PRODUCT OF THE MONTH



SolidWorks Corp. (Concord, MA) has released SolidWorks 2003, the latest version of the company's 3D CAD software. New capabilities and enhancements include faster rollback and editing of models, feature level control over multiple bodies, and improved Smart Mates, which help users gather and assemble the pieces in a design. Users can pre-define mating scenarios so components can be fully oriented in a single step. The new version includes the ability to drive models with springs, motors, and gravitational forces, testing how mechanisms with contact forces will interact when in motion. Improved interoperability with legacy AutoCAD files lets users drag 2D sketch or drawing geometry into SolidWorks drawings or sketches for 3D feature creation. A new component of the software is COSMOSXpress, which lets designers conduct up-front analysis on part designs directly in SolidWorks. Also new in this version is 3D ContentCentral, an online resource that helps users find the supplier part or assembly they need via a Web site with hundreds of millions of downloadable solid models from leading component manufacturers. The resource also provides a constantly updated library of customer-contributed models for sharing.

For Free Info Visit www.nasatech.com/solidworks

What's New Online

Have you visited the Technology Focus Products Page on the NTB Web site? After you read about the latest NASA technologies in the field of Engineering Materials in this issue (beginning on page 30), you can go to **www.nasatech.com/techfocus** and find information on the latest materials on the market.

For each month's Technology Focus in NTB, you'll find on the new Web page descriptions and photos of new commercial products in that same subject area, along with links to the vendors' Web sites. Check out this new, exclusive Web feature at **www.nasatech.com/techfocus**.

JPL Opens One-Stop Technology Shop

Last month, NASA's Jet Propulsion Laboratory (JPL) in Pasadena, CA, opened its Commercialization Center, a one-stop shop for U.S. companies that want to work with JPL's Commercial Technology Program to develop and transfer technologies. Many technologies developed at JPL already have skyrocketed on Earth due to strategic business alliances.

"It will literally be the front door to companies who wish to work with us but who don't know quite where to go," said Merle McKenzie, manager of JPL's Commercial Technology Program. "The Commercialization Center will provide access to information on JPL's unique capabilities and technologies, expertise, research and development, and services geared toward business."

On average, JPL reports nearly 300 innovations per year and roughly 150 new business partnerships. The Commercialization Center will be the gateway to:

- *Licensing JPL Technology* — The Caltech Office of Technology Transfer is responsible for the licensing and transfer of technologies from the California Institute of Technology and JPL.
- *Technology Affiliates* — Any U.S.-owned organization can access JPL's special technological expertise through the Technology Affiliates Program, which provides tech transfer and help for developing new or improved products and manufacturing processes, where JPL does not compete with U.S. industry.
- *Technology Cooperation Agreement* — These agreements create dual-use technology development arrangements with no exchange of funds. JPL and its partner company leverage each other's intellectual property and expertise for NASA goals and commercial use.

- *Small Business Tech Transfer* — The program provides funding to small businesses interested in undertaking research and technology development on topics identified by five U.S. Government agencies.

For more information on the JPL Commercialization Center, visit ***http://techtransfer.jpl.nasa.gov/index_flash.html***.

Next Month in NTB

The December issue will include all of the nominees and voting information for our 2002 Product of the Year Awards. This is your chance to choose the most significant new product introduction of the year from the 12 nominated Products of the Month. Also in the December issue will be a feature on developments in Test Instrumentation that will include the latest innovations in computer-based measurement.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NASA Patents

Over the past three decades, NASA has granted more than 1000 patent licenses in virtually every area of technology. The agency has a portfolio of 3000 patents and pending applications available now for license by businesses and individuals, including these recently patented inventions:

Shape Memory Alloy Actuator

(U.S. Patent No. 6,367,250)

Robert J. Baumbick, John H. Glenn Research Center

Shape memory alloys, such as the nickel-titanium type, exhibit the ability to return to a predetermined shape when heated. When it is cold, it exhibits low yield strength and can be deformed easily into any desired shape, which it will retain. This invention is a microactuator control apparatus using shape memory alloy (SMA) elements activated by applying thermal energy, either from a high-temperature gas or an optical source.

In the hot gas embodiment, the flow of hot gas to the SMA elements is controlled by optically operated switches or gates. In the optical energy embodiment, optical energy such as laser energy may be applied directly to the SMA elements using optical energy transmission means. The hot gas and/or optically operated SMA actuators are particularly suitable for use on gas turbine-powered aircraft.

Laser Image Contrast Enhancement System

(U.S. Patent No. 6,366,403)

Robert L. Kurtz, Richard R. Holmes, and William K. Witherow, Marshall Space Flight Center

This optical image enhancement system provides improved image contrast in imaging a target in high-temperature surroundings such as a furnace. The optical system includes a source of vertically polarized light such as laser light, and beam splitter for receiving the light and directing it toward the target. The system provides an on-axis, monostatic mode of operation that permits the system to interface with a much smaller opening. The device can be made quite small and compact.

A band pass filter is disposed along the optical path downstream of the circular polarizing means, which has a band pass filter characteristic matching the frequency of the light beam produced by the light source. A charge-coupled device (CCD) camera is positioned along the optical path for capturing the high-contrast image.

Helicopter Tail Boom With Venting for Alleviation and Control of Tail Boom Aerodynamic Loads and Method Thereof

(U.S. Patent No. 6,352,220)

Daniel W. Banks and Henry L. Kelley, Dryden Flight Research Center

A helicopter with a single main rotor must employ some means to counteract the torque produced on the fuselage of the helicopter by the engine turning the rotor blades. The forces exerted by the engine against the rotor blades will, if not counteracted, cause the fuselage to rotate in a direction opposite to that of the main rotor. Such rotation could cause the helicopter to crash. An apparatus provides sufficiently reduced loads on the tail boom so that improved maneuvering of the helicopter can be obtained.

The apparatus provides a flight vehicle tail assembly with an exterior surface, one or more first or high-pressure vents in the exterior surface, one or more second or low-pressure vents in the exterior surface, and an air passage connecting both vents, allowing air to flow between them. The invention alleviates adverse aerodynamic loads on the flight vehicle tail assembly. The apparatus receives air through one or more high-pressure vents in the exterior surface, passing it through the tail assembly from the first vent to one or more second vents in the exterior surface, and ejecting the air out of the tail assembly at the second vent.

The vents reduce the sensitivity of side forces with changes in inflow angle. The system also provides control and alleviation of the dynamic forces, including vibration, on the boom. The invention is passive in nature and does not require power to be drawn from the engine.

For more information on the inventions described here, contact the appropriate NASA Field Center's Commercial Technology Office. See page 10 for a list of office contacts.

Technologies of the Month

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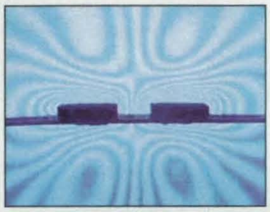
For more information on these and other new, licensable inventions, visit www.nasatech.com/techsearch

Anti-Vibration Technology Combines Springs with Electromagnets

BAE Systems

The passive mounts and spring systems commonly used to absorb machinery vibration can stimulate resonance in the base and lead to additional problems. BAE Systems has developed the Smart Spring™ mount concept, which combines passive main load springs with an electromagnetic assembly that anticipates vibration using force and accelerometer sensors to eliminate vibration being transmitted to the support base. This new approach does not require a rigid base or supporting structure. Instead, both elements of the system can "float," with the passive load springs supporting the mass of the object and the electromagnetic assembly providing active control that accommodates varying loads and vibration conditions.



Smart Spring™ technology is suitable for both heavy-duty and precision anti-vibration applications.

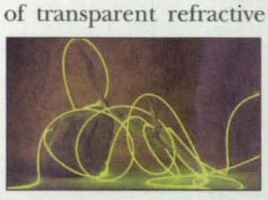
Get the complete report on this technology at:
www.nasatech.com/techsearch/tow/baespring.html
Email: nasatech@yet2.com
Phone: 617-557-3837

Simple, Versatile Approach to Dispersing Light

Bridgestone Corporation

When plastic optical fibers are used to scatter light, one or more plastic fibers have to be processed into a ribbon form and scratched to create reflective surfaces, which results in varying amounts of light being scattered. The need for a larger diameter fiber also decreases its flexibility.

Bridgestone has developed optical waveguide tubes made of transparent refractive materials embedded in a flexible, transparent, elastomer matrix. Because all the materials used are transparent, no light is absorbed and light efficiency is high. The tubes can be formed into virtually any shape including fibers, rods, films, plates, pipes, wedges, cones, and domes.



A hollow, transparent cladding tube with one open end is filled with a monomer that is polymerized while applying uniform pressure axially to both ends of the tube. When the polymer is mixed with a phosphate, the waveguide is capable of maintaining its high light transmittance in hot, humid environments.

Get the complete report on this technology at:
www.nasatech.com/techsearch/tow/bridgestone.html
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Anti-Reflective Film for Optical and Display Applications

Dai Nippon Printing Co., Ltd.

Everything from cell phones and laptops to navigational systems in cars and aircraft use displays for communication and information. With plasma and liquid crystal displays, the concern is being able to view the screen from all angles. Anti-reflective and low-refractive screen films open the viewing cone considerably. But it is difficult and expensive to create these films.

DNP has developed a cost-effective method for producing anti-reflective film using a sol gel process. By incorporating silicon dioxide into the low-temperature sol gel method, a low-refractive-index film can be produced that significantly improves the anti-reflective properties of the display. The film can be used in computer, television, and plasma displays, and in mirror surfaces and window glass.

Get the complete report on this technology at:
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High-Purity Precious Metal Particles for PCBs

DuPont

The shrinking form factors and growing complexity of electronic products require printed circuit boards (PCBs) with ever-narrowing conductive lines and tinier electrodes. Thus, board-level signals are being conducted over pathways created from minute particles of precious metals, such as gold, silver, palladium, and copper oxide. The particles must be uniform in size, composition, and purity in order to form the necessary dense, narrow, uniform lines. DuPont has developed a manufacturing technology that incorporates metal precursors in an aqueous solution, and synthesizes the particles out of an aerosol generated from that solution.

The result of this process is a powder of pure, fully dense, compositionally uniform, spherical particles of a common size. The powder is ideal for conductive thick film pastes used in a variety of electronic component manufacturing applications.

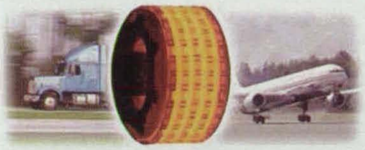
Get the complete report on this technology at:
www.nasatech.com/techsearch/tow/dupont-pcb.html
Email: nasatech@yet2.com
Phone: 617-557-3837

Carbon Composite Manufacturing Technology Improves Brake Performance

Honeywell

Carbon composite materials offer unique physical, thermal, and chemical properties that significantly improve performance for disc brake systems. Honeywell uses a ceramic solution to enhance carbon's characteristics, yielding improved wear rates without sacrificing friction performance.

A colloidal ceramic solution improves the densification rate. However, the water-based ceramic solution is not readily accepted by the carbon preform, so chemical surfactants are used to achieve good penetration into the pore microstructure. By submerging the carbon preform into a slurry and applying a vacuum in a submerged state, the colloidal solution is forced into the open pores. Variation in the ceramic loading levels can be used to achieve the desired friction and wear properties.



The technology is suitable for manufacturing aerospace, automotive, and heavy truck carbon/carbon disc brakes, as well as for use in virtually any application where high friction/low wear is required.

Get the complete report on this technology at:
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Termination Process Enables Cost-Effective Manufacturing of Tunable Optical Fibers

Northrop Grumman

The advantages of optical fiber over copper cabling are many. The disadvantage is terminating the fiber or preparing the fiber ends for connection to something. When the stream of binary code transported by a designated wavelength of light is disrupted, problems occur. To terminate optical fiber, one needs to slice through thousands of microscopic glass fibers at just the right angle without chipping or fracturing the glass.

Northrop Grumman has changed the fiber geometry in the attenuation area during manufacture. By creating a tapered end, the light-absorbing layers are squeezed closer to the core, causing more light to escape the core and be absorbed by the secondary layer. As the fiber tapers, propagating light encounters the quenching region and is absorbed, reducing the potential problem. The tapering is accomplished using current fused biconnical tapering methods. This technology can be used anywhere along the length of the fiber.

Get the complete report on this technology at:
www.nasatech.com/techsearch/tow/northrop.html
Email: nasatech@yet2.com
Phone: 617-557-3837

TechNeeds — Requests for Technologies

TechNeeds are anonymous requests for technologies that you and your organization may be able to fulfill. Responding to a TechNeed is the first step to gaining an introduction with a prospective "buyer" for your technology solution.

Food Ingredients

A multi-million-dollar European organization is seeking unique food ingredients proven to be capable of enhancing cognitive functions and mental performance. Their intention is to base solid and liquid food products, or dietary supplements, on the ingredients.

The problem they face is that many herbal extracts are not scientifically proven, and may not be allowed in food products consumed by humans. Molecules, extracts, precursors, and various delivery systems are open for consideration.

Respond to this TechNeed at:
www.nasatech.com/techsearch/tn/food.html
Email: nasatech@yet2.com
Phone: 617-557-3837

Technology to Prohibit Counterfeiting and Alteration

Technologies are needed for flexible substrates such as paper, film, textiles, or non-wovens for security documents or brand protection products that allow easily recognizable authentication, as well as features to obstruct counterfeiting, copying, or alteration.

The technology must be embedded within, or applied to, flexible substrates by means that will allow further processing of the base substrates. The technology also must allow the end-user to easily verify that a document or product is authentic, but not be cleverly duplicated, counterfeited, or altered. All technologies must pose no hazard to human health or safety, or the environment, and be stable in heat, moisture, and sunlight.

Respond to this TechNeed at:
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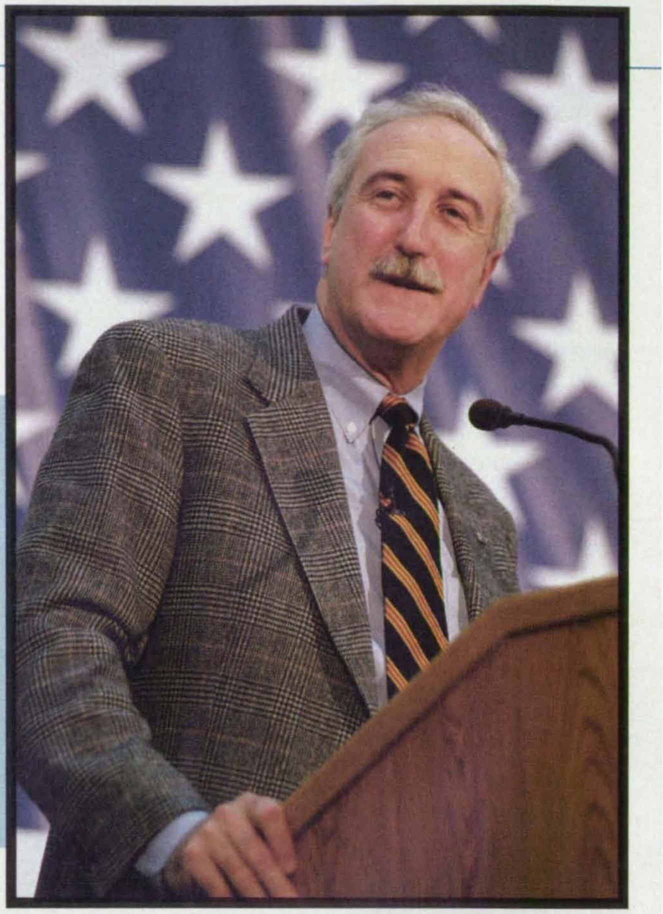
NASA Administrator Sean O'Keefe

Although Sean O'Keefe has yet to complete his first year as NASA Administrator, his vision for the agency is well in place. Administrator O'Keefe has set a mandate that consists of three goals: 1) To improve life here; 2) To extend life to there; and 3) To find life beyond.

O'Keefe came to NASA in January of this year from the Office of Management and Budget, where he served as Deputy Director, overseeing the preparation and management of the Federal budget. His previous positions included Secretary of the Navy in 1992, and Comptroller and Chief Financial Officer of the Department of Defense in 1989 under then Defense Secretary Dick Cheney.

Recently, *NASA Tech Briefs* sat down with Administrator O'Keefe to talk about his first ten months in office, including the expected — and unexpected — challenges he's faced.



(NASA/Renee Bouchard)

NASA Tech Briefs: **From a scientific research standpoint, how can NASA and its partner agencies best use the International Space Station?**

Sean O'Keefe: The European, Russian, Japanese, and Canadian space agencies all have a different way of going about their research objectives. A group of scientists and technical people from all of the different scientific communities represented in biological and physical research, materials research, etc., looked at the expectations that the scientific community had for what was to be performed on the station, which up until that time, all had equal priority — everything was number one. What I found amazing was that the Russian and Canadian space agencies — and to a different extent, the Japanese space agency — were most enthusiastic about joining us in the proceedings. The European Space Agency said it was interesting, but they wanted to follow their own procedure.

How we intend to use the station will be informed by this scientific agenda. We're organizing what the capabilities are in a way that is now more logically driven by a scientific and research agenda.

NTB: You said this spring that NASA is at a crossroads and what the agency needs is a roadmap to continue its work in a more efficient, collaborative manner. What steps have you taken toward that roadmap?

O'Keefe: There are three things involved. The first step in that direction is to bolster and renew the credibility of the agency. One classic example, one signature kind of problem that has compromised that credibility is the Space Station. We are working feverishly to not only do it right and to field an International Space Station impressively, but to do so in a way that restores our credibility that when we say something, we're going to do it and we mean it.

The second step is to vigorously pursue enabling technologies. Those really require the collaboration on the part of several NASA centers and enterprises to accomplish the task. The most graphic example of an enabling technology is figuring out a way to get anywhere faster than we do today. At flank speed, the best we can do in getting to the Moon is 25,000 miles per hour.

Hence, the Nuclear Systems Initiative, which is not necessarily an energy source of absolute preference. In my mind, it's a good one, but there may be better ones out there. It certainly is the most mature, so let's get on with it. In the process of getting on with it, we're going to at least triple the in-space propulsion speed that we're able to accomplish in the next five years. It is on an aggressive course within that five-year span, and I'd like to step that up even faster. We're looking at what appropriate missions would be demonstrators of this capacity within this decade. It's a technical challenge.

But it's going to liberate us from what has been a continuing challenge in the 44 years of this agency. And more importantly, it will open up a whole new range of technologies that will accomplish that objective even more proficiently. The best we can do right now is a fly-by. We're stuck with the basic laws of physics. If the camera doesn't work exactly right when you're in the fly-by, that's it. It really requires that we have the capacity to maneuver and operationally adjust to all those things, and the Nuclear Systems Initiative gives us the chance to do that.

As far as other agencies, we'd be dealing with the Department of Energy in two parts of the DOE chain: the nuclear energy side, which is the commercial nuclear side or the civil nuclear applications end of it, and the folks we're looking to for design prowess, the Naval reactor guys. They are now able to develop and build reactors that go aboard attack submarines that are roughly the size of a trash can and generate enough power to get a nuclear powered submarine moving. We don't need anything

nearly that elaborate. What we need is something that generates enough power to propel and keep the lights burning on the space probe for an extended period of time. This is easily done without incident.

The other area that requires collaboration is on the human endurance, or human effects side. The bioastronautics of human endurance in space flight is something we don't know a lot about. It's sobering to realize that we just hit the American record of longest duration in spaceflight at 196 days. It takes longer than that to get to Mars, much less back. And we are big fans of round trips. The condition of the two astronauts who set the American record when they came back was not insignificant. The muscle mass loss was on the order of 20%. More significantly, the bone content and mass loss was verging on 5 to 10%, which is degenerative to the point of no recovery likely. Every one of the missions has had this kind of consequence. We don't even know what the consequence is, even just in low-Earth orbit, of folks receiving the equivalent of eight chest x-rays every day. If we're not certain what the human endurance capacity is, we better go figure this out in record time.

In the process of doing so, it will open up a whole range of other opportunities, not only in terms of human spaceflight, but also immediate, near-term challenges. If we can figure out how to arrest bone mass degeneration, and stop it in that accelerated atmosphere, we're talking about minimizing the likelihood that any of us will suffer from osteoporosis by the time we're older. It is a technological challenge we've got to conquer.

The third step in setting our course is to concentrate on capabilities to ultimately pursue exploration objectives beyond low-Earth orbit. The Space Launch Initiative and other plans have all concentrated on how to get there faster. So until we can map out and chart an approach of how to deal with this, we're kind of restricted to the same exploration objectives. To wit, what we're doing on Mars right now. We spent the last two years mapping it, understanding the climate conditions, the topography, and where the optimum landing sites are. Step two is sending the rovers. It will be a while before we get the answers back from those. And maybe one of these days, we may be able to get humans there, or any place they want to go.

NTB: In talking about space exploration, how big a priority is it to go back to the Moon?

O'Keefe: There are many reasons why the Moon may be a very useful destination for longer-term objectives. If the science and research objectives will take you to somewhere, and in that intervening step, you need to be at the Moon for staging in order to accomplish that task, then that seems like a perfectly plausible view, but I haven't seen that demonstrated yet. I don't know that there is a science or research objective that has been defined as to why we'd want to go back.

NTB: One of your mandates is "to improve life here." How has that changed since last September 11, and how can NASA's capabilities be used to support the nation's security and defense?

O'Keefe: In the immediate aftermath of September 11, we stepped up a serious technology research and development effort that had been underway in a nascent form to look at how we employ the technical or operational means to control commercial aircraft beyond a certain point. What the people at Langley Research Center have developed is a capability that's been operationally tested that would provide ample warning to pilots whenever they're approaching inanimate objects: mountains, buildings, etc. At the point at which there is no longer an indicator that the pilot is receiving the warning, and after ample efforts at trying to do so, there is a capability to automatically assume and divert without human interference. That could be very useful for a lot of reasons, and it certainly would be useful for the purpose of attempting to negate the prospect that anyone would ever seek to use a commercial airliner as a weapon again. What you'll see in the coming year is even more aggressively implementing that aerospace/aeronautics technology for safety and security purposes.

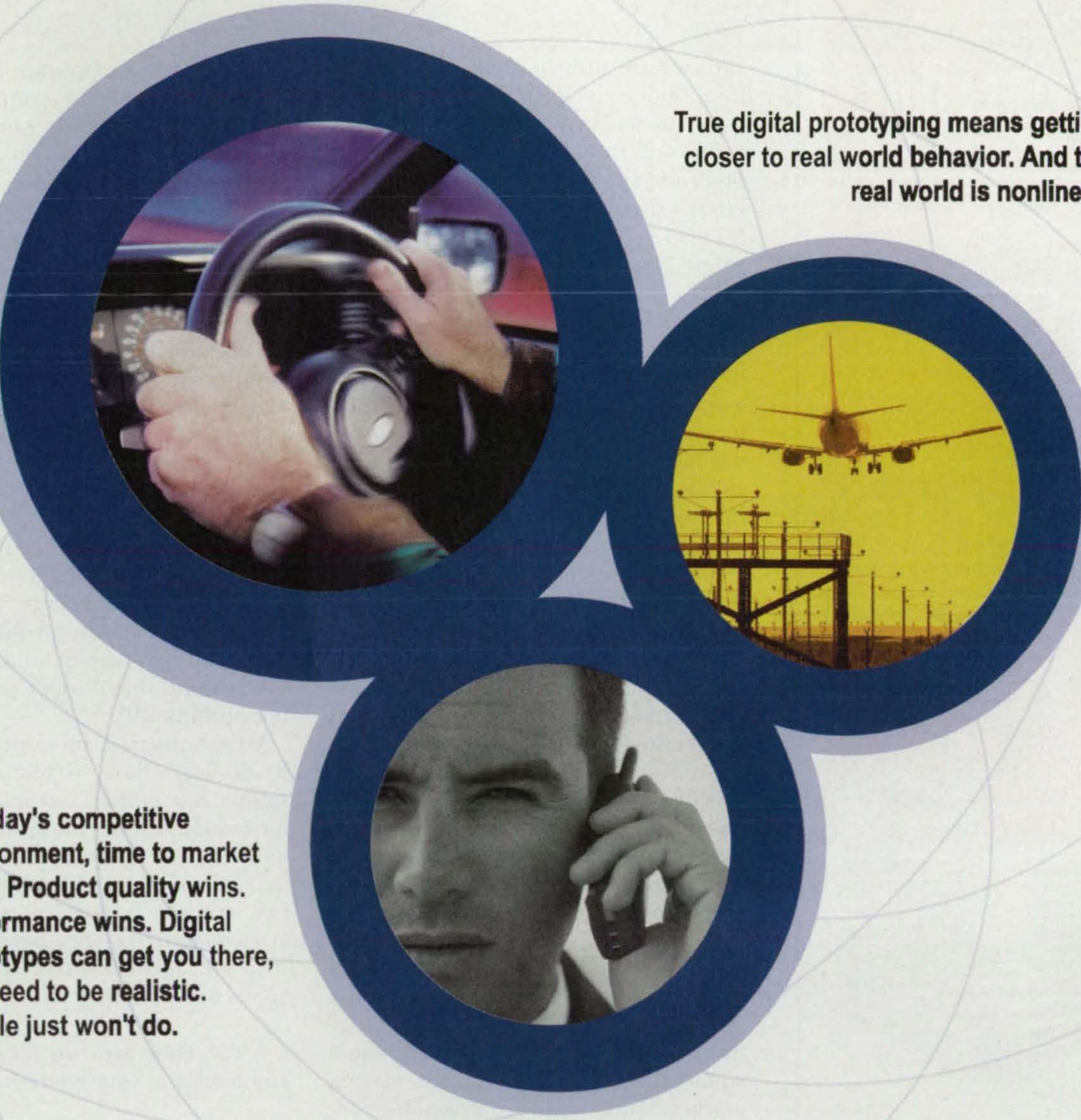
"We have an obligation to make the information we have, the technologies we have, and the technical breakthroughs we've experienced as widely available as possible."

In the Earth sciences area, we have Earth-observing satellites, which provide extraordinary all-access, all-source availability of geological, geographic, and topographical terrain condition, as well as analysis of weather patterns. That proved to be pretty handy stuff during the Afghanistan campaign. What we thought was a nice way to map and chart climate change alternatives proved to be a useful instrument.

As part of his first tour of Langley Research Center in Hampton, VA, Administrator O'Keefe checks out a cockpit simulator. (NASA/Bill Ingalls)

NTB: How can NASA, in turn, help the airline industry out of its current crisis and instill confidence in the American public that it's safe to fly?

O'Keefe: The best way we can help on that front is to exert some creativity in our role as the FAA's research and development house and try to put a serious dent in the challenge of air traffic management problems. That's a real plague on most of the airlines, particularly since September 11. The ineffi-



ciencies are unbelievable. We have efforts underway at Ames Research Center in air traffic management systems.

Beyond that, some aeronautic designs and capabilities are mostly on the safety side of the equation. We are the NTSB's (National Transportation Safety Board) forensic house for diagnostics on what prompted failures in a number of different settings. Most notable was the American Airlines crash in New York last November. We've been working through the analyses and forensics of the composites on those aircraft to ascertain not only what structural changes ought to be made by the airlines, but also what operational changes ought to be considered by our own air traffic management system on the takeoff and landing of aircraft. At least a portion of the story appears to have been, from what I gather, the traffic patterns and the operational conduct of takeoff and landing conditions that existed at JFK Airport that day.

NTB: Our readers are design engineers who directly benefit from NASA's technology transfer program. How essential is this program to your vision for NASA?

O'Keefe: I am a died-in-the-wool economist and I am of the mind that the market has to drive technology transfer efforts. We are singularly inadequate in this agency at forecasting market changes that are driven by commercial demand. We're not great at that, nor should we expect to be.

At the same time, we do have an obligation to make the information we have, the technologies we have, and the technical breakthroughs we have experienced as widely available as possible, short of export control limitations. Our obligation is to make it accessible, available, and understood as widely as possible. You do that not only by open access policies, but also proactively, participating in all kinds of different areas where folks from lots of different market disciplines that you never imagined come rolling through and say, 'We've been looking for just that thing.'

It stuns me that someone like the legendary Dr. Michael DeBakey came up with the heart pump valve improvement in the last year from a casual conversation he had with a NASA engineer. No tech transfer program could have possibly created that opportunity. It's got to be a certain level of serendipitous event. We must proactively do our best to permit those events to happen as widely and broadly as we possibly can.

NTB: What inspires you about NASA, and what has surprised you in your ten months as Administrator?

O'Keefe: There isn't anybody in this country who has looked at what this agency does with disdain. This has always been a very energetic, extremely inspirational kind of agenda that the agency has had. If there is a limitation, it's that it harbors everybody's fondest hopes, dreams, and expectations of what it is we think we ought to be capable of as human beings. We're never going to succeed in all those expectations. But that sure is a wide-open portfolio. And if that doesn't get you juiced up, nothing will.

What surprised me most, and maybe it shouldn't have, is that there is absolute, raw enthusiasm in this agency, no matter where you go. And I don't need to go around having morale-building sessions. In every discussion I've had with folks at centers as well as at Headquarters, they have a very constructive agenda where we're talking about issues, talking about challenges.

NTB: How are you leveraging that enthusiasm in your education initiative?

O'Keefe: That's easy. Among the three goals we've set for ourselves, inspiring the next generation of explorers — you've got to do that. The information is right here. It's just a matter of how you package it and find a different way of making it readily, easily accessible to everybody from the principal investigator at the most high-end university engineering school you can imagine, to the third-grade teacher who can press a button and say, 'Let me show 20 kids what is going to get them juiced up to want to do this when they grow up.' It just takes imagination and innovation. It's a joy to recruit people who come into this operation as educators or as folks who really can excite kids, and say to kids, 'How'd you like to work here at NASA?' and see their eyes light up. It's the proverbial kid in the candy store.

*A full transcript of this interview appears on-line at **www.nasatech.com/whoswho**.*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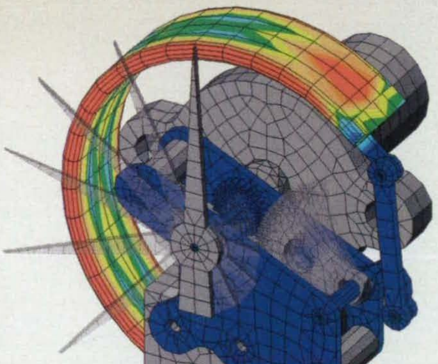
Balancing Functionality and Ease of Use in Analysis Software

When we highlighted the analysis and simulation software industry last November, the major issue facing vendors and their customers was ease of use. Not surprisingly, that continues to be an important issue today.

Computing environments such as Windows have raised designers' expectations for point-and-click analysis software. "Users really do expect their analysis and simulation tools to be just as easy to use as other Windows software," said Bob Williams, product manager for finite element analysis software provider ALGOR, Inc. "The school of thought used to be that designers only wanted things to be easy and they rarely needed power, where analysts primarily wanted power and were less concerned about ease of use. Those lines have completely blurred. No matter at what level they're using the software, users want it to be easy to use, and they want it to increase their productivity," Williams added.

The danger, though, said Williams, is going to the opposite extreme. Vendors have to be careful about "simplifying the software so much that you lose the power that your users need. Our approach is that whether you're an entry-level designer or an experienced analyst, you want software that can quickly perform common tasks, while still providing more advanced features without having to learn another more difficult user interface."



In this Mechanical Event Simulation of a Bourdon pressure gauge performed with ALGOR software, the model uses kinematic elements and surface-to-surface contact elements between the gears to replicate the motion of the indicator needle as pressure is increased within the tube.

Vendors and users also need to recognize that there are two aspects to ease of use, according to Ken Short, vice president of marketing for ABAQUS, Inc., makers of ABAQUS simulation software. One aspect is "how to make the traditional users or expert analysts more productive by making the software easier to use — it's about accessibility and productivity. The second aspect is how to put the technology into the hands of an inexperienced or infrequent user." Making the software easy to learn and becoming productive with the software quickly are two different things, Short said.

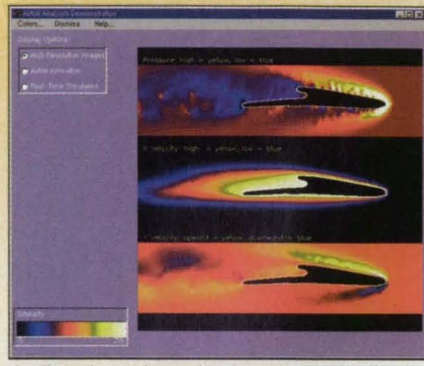
Another issue that hampers ease of use is the fact that old, outdated code that was difficult to learn and use 20 or 30 years ago is still in use in some cases today. Not being able to adapt older code to today's standardized graphical user interfaces and dialog boxes only helps to hinder new users, said Bjorn Sjodin, vice president of engineering for COMSOL, which provides FEMLAB multiphysics analysis and simulation software.

"There are actually many software vendors running code today that was developed in the 1970s. That software is evolving, so it's not really easy to use, and it's not being adapted to the latest Windows standard technology," Sjodin explained. "You really need to start over again to reinvent and rebuild the software using the possibilities that are around today."

Noran Engineering's product, NE/NASTRAN, for example, is finite element analysis software based on the NASTRAN code originally developed by NASA. Noran's challenge was to make the software easier to use. "NASTRAN by itself is very scary," said David Weinberg, president and CEO of Noran Engineering. "It was written by programmers for programmers. It isn't for designers or novices learning FEA. We took the power behind the code and made it easy to use."

The phrase "less is more" applies in many ways to how vendors should be looking at ease of use. "If the software ties specifically into the process or the type of structure they're simulating, people should be able to be productive from day one," according to Ken Blakely, executive vice president of MSC.Software. "It's specific to what you do, without giving you any additional bells and whistles. Sometimes it's those extra bells and whistles that get in the way of people becoming productive."

Ease of use becomes even more important as the amount of data to be processed and the level of complexity of simulations and analyses increase. "Software is actually getting more complicated, but at the same time, users demand that the software must be easier to use," said Dr. C.P. Yang, president of OriginLab, a provider of scientific graphing and analysis software. "Users want to open the software, install it, and see results right away. People get used to point-and-click," Yang added, "and then they expect, no matter how complicated the task, that it will still be point-and-click."

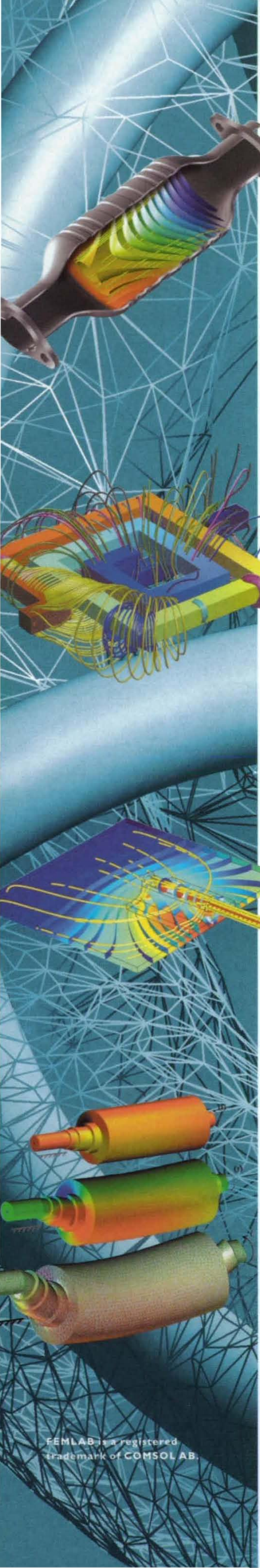


The flow of a wind tunnel is shown in this airfoil analysis performed with PV-WAVE from Visual Numerics.

Where CAD Fits In

Many CAD vendors are incorporating more analysis and simulation capabilities into their software in an effort to offer a one-stop shop for designers and analysts. SolidWorks, for example, recently released SolidWorks 2003 CAD software that includes COSMOSXpress, which lets designers conduct up-front analysis on part designs directly in SolidWorks. The new component is one of the COSMOS™ family of analysis tools from Structural Research & Analysis Corp. (SRAC).

Mike Wheeler, vice president and general manager for the Mechanical Business Unit of ANSYS, a simulation software provider, wonders if CAD-embedded simulation is good for a company's growth. "The issue with simulation integrated into CAD is how that integrated product grows as the company's simulation needs grow. If you can



The most common reactor for environmental protection, which we encounter or use everyday, is the catalytic converter in automobiles. In these monolithic catalysts, carbon monoxide and nitrous oxides are converted into relatively harmless species like carbon dioxide and nitrogen. To optimize the utilization of the expensive catalyst, it is important to be able to model the reactor at different operational conditions. In this FEMLAB model, mass and heat balances are coupled to compute temperature distribution and flowlines in the reactor.

This square-shaped spiral inductor is used for bandpass filters in micro electromechanical systems (MEMS). The FEMLAB simulation takes the nonuniform current density in the coils into account to compute an accurate magnetic flux arround the coils. The inductance of this inductor is 2.1 nH, which is obtained by integrating the magnetic energy. Using the programming language of FEMLAB for parametric analysis, you can find the correlation between the induction and the input parameters of the model.

In the design of electrodes for water electrolysis, it is important to minimize the voltage losses at a given total current. FEMLAB modeling helps the engineer in the design of the electrode geometry and the current collector. The model gives the current density distribution and the potential distribution in the system. These results make it possible to avoid excessive degradation of the active electrode surface and overheating of the welds at the position of the current collector.

When designing an electric motor it is important to design the rotor shaft so that no eigenfrequencies exist in the working range of the rotational speed. It is also important to study the shape of the eigenmode and not just the eigenfrequencies. In the eigenfrequency analysis, one end of the shaft is fixed and the other end is free to rotate and axially deform. The image shows deformation and rotation angle in the second eigenmode, using different visualization options like colormaps and scaling.

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say to a company, 'this is all you're ever going to need in the way of simulation,' then that might be a reasonable solution. When the customer needs to grow into other areas, they have to start all over again and it really doesn't become a strategic part of their overall simulation and design process strategy. It becomes a tactical, short-term solution," said Wheeler.

Short believes that CAD-integrated analysis has its place, but is also skeptical about how successful it will be in the long term. "The general-purpose, lightweight FEA code built into a CAD system has its place, but in terms of really making the impact we all thought it was going to make, I don't think it's going to happen."

In this analysis performed with ABAQUS software, inertia relief is used to simulate braking loads in a truck chassis assembly.

According to Weinberg, embedding analysis in CAD programs makes analysis too easy, which can be dangerous. "It's okay to have designers doing analysis, but if you make it too easy, the designer has no incentive to really learn what's going on. And if they don't know what's going on, they won't be able to tell when the code is wrong. It's a matter of garbage in, garbage out," he said.

"You can get beautiful contour plots that look great, but they can be completely wrong, and in the end, you end up with tests or hardware that fail," Weinberg said.

Tying analysis to a design program does have advantages, particularly when they can work together to help streamline the design process and support ease of use. "There's no question that the industry has been working to provide analysis and simulation tools to better support the design process," said ALGOR's Williams. We have focused on providing a modern, single user interface that seamlessly integrates with most popular CAD tools for any analysis type."

COMSOL's Sjodin agrees that by combining the two, users will be the ultimate beneficiaries. "The CAD business has always been tightly connected to the physics modeling and simulation business. It's pretty natural that CAD is starting to approach our market," he said. "If you don't have the best CAD program to do your tasks, you can't do it in the physics modeling software, either. By combining the two, both sides reach new market segments. It's beneficial for both."

Getting analysis capabilities into the hands of people who use CAD is not just important to the CAD companies, but also is becoming a priority for the CAE software vendors as well, according to MSC.Software's Blakely. "CAD-embedded solutions are one way to bring simulation to a wider variety of people, and to facilitate ease of use. It's not just CAD companies putting simulation in their products, it's also the analysis companies as well. I expect to see this trend continue."

Looking Ahead

As with many industries in the current economy, analysis and simulation software vendors are taking a close look at their market and their current and prospective customers. Most vendors see this market segment growing, as more and more companies recognize the importance of accurate modeling, visualization, and simulation of their products.

"Finite element analysis is mature now. I think FEA is ready to cross the chasm, and people are going to start wanting to do some of the things that were deemed to be somewhat exotic and somewhat of a luxury in the past," said Short. "People are going to start expecting to do these really sophisticated reality-based simulations as part of their routine engineering."

Using more sophisticated simulation tools with extended capabilities also allows users to see their data differently, according to Sean Fitzgerald, vice president of technology for Visual Numerics, provider of PV-WAVE analysis and visualization software. "In simulation and visualization, there is always a need to better understand your data. We're seeing more use of three-dimensional displays, and companies are seeing the value of being able to look at their data in different ways to identify trends or anomalies that they otherwise may not have seen."

The goal, according to Blakely, is to be able to simulate a product's entire lifecycle, from conception to disposal. "We want to simulate more and simulate more accurately," he said. "That's a trend from the industry as a whole." Another trend Blakely sees is that simulation also is being used earlier — in the concept stage — where the design tradeoffs can be made quickly.

The major improvements that users will see may come as a result of hardware, rather than new software technologies, said Sjodin. "There are practically no new software technologies being invented — everything new that comes to the market comes from increasing power of the hardware," he added. "In 10 or 20 years, computers have become thousands of times quicker and better in every respect. The software technology may only be a couple of times better."

Leveraging those hardware improvements is important to companies like ALGOR, said Williams. "Now that users can do things faster, they can consider more physical factors with the software, which leads to trying to find ways to better leverage hardware improvements," he said.

So while the analysis and simulation software market continues to grow, and ease of use continues to improve, there is still a long way to go, according to ANSYS' Wheeler. "We still can't analyze an entire airplane and get detailed stresses. We still have a lot of approximations we make," he explained. "We think this is a great market opportunity. If I can create a product that will allow an auto company to create one simulation model of a car and crash it into a wall, run it over a road simulator, and get the complete details from one analysis in a reasonable amount of time, the value to the customer would be unbelievable."

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Cardiac Monitoring System Aids Astronauts

EASI™ 12-Lead ECG Monitoring System
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In order to track the cardiovascular health of long-term residents aboard the International Space Station (ISS), NASA is using Philips Medical Systems' EASI™ 12-Lead heart-monitoring system, which combines an innovative algorithm and electrocardiogram (ECG) monitor. The EASI system and the Tango Stress BP Monitor are used on a monthly basis by NASA to monitor astronauts' health as part of the agency's Crew Health Care System (CHeCS).

While traditional 12-lead ECG systems typically employ 10 electrodes with cables that attach to the body, Philips' EASI 12-Lead algorithm enables derivation of 12 ECG leads using only five electrodes, which enables astronauts to maintain a higher level of mobility. Reducing the number of electrodes also makes the system easier to use, increases accuracy, and lowers signal noise.

Electrodes are placed on the astronaut's upper sternum, lower sternum, and on the right and left midaxilary lines at the same level as the lower sternum electrode. The fifth electrode can be placed anywhere.

ECG systems detect and document cardiac arrhythmias and ST changes during continuous monitoring. ST refers to the segment of the ECG waveform from the S wave to the beginning of the T wave. Elevated ST segments are often an early sign of a heart attack. Alternatively, a depressed ST segment indicates that the heart isn't receiving enough oxygen. This decrease can result from increased demand (exercise), decreased blood flow (narrowed or partially blocked coronary artery), or both.

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Antenna Ensures Communication Between ISS Crew Members

Orlan Antenna
Georgia Institute of Technology
Atlanta, GA
770-528-7067
www.gtri.gatech.edu

An astronaut in the new airlock, which includes the Orlan antenna.

The dual-band Orlan antenna, designed and built at the Georgia Institute of Technology for NASA and the Boeing Co., now serves as a critical part of the communication system on the International Space Station (ISS). The antenna allows crew members to verbally communicate with astronauts wearing Russian-built Orlan spacesuits. It also transmits the astronauts' vital signs as well as data regarding the condition of their spacesuits.

Part of the Russian spacesuit's insulation system consists of a conductive metal film. This film also serves as the antenna. The upper and lower halves of each suit are isolated from one another. These suits operate on frequencies of 120 and 250 MHz, which are just short enough to resonate inside the airlock. Orlan is not used in conjunction with U.S.-designed spacesuits because they have a discrete antenna.

The antenna posed a number of additional design challenges. Orlan needed to be sturdy enough to survive large swings in temperature (approximately -40°F to 170°F) and withstand physical battering from astronauts and their equipment as they enter and exit the ISS's air lock during construction, maintenance, and other activities. The antenna also needed to work reliably inside the conductive air lock structure, which has a mere 63" diameter, despite constantly changing electromagnetic energy patterns that vary with the movement of astronauts.

The resulting Orlan antenna employs a half-loop design — resembling a towel bar — made out of nickel-plated aluminum. The 2-foot-long bar rises 4 inches off a wall in the ISS's air lock and doubles as a hand- or foot-hold.

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Lightweight Foam Pads for Helmets

Special formulations are selected to obtain desired properties.

Lyndon B. Johnson Space Center, Houston, Texas

Special foam pads have been developed for use in helmets. The foams in these pads have been formulated to obtain a combination of light weight, resistance to oxidation, flame retardance, superior shock-absorbing properties, and physical comfort during long use. In the original application, the pads are intended especially for use in supporting the heads of reclining astronauts during launch, providing a slight upward tilt so that the astronauts can see critical panels, switches, and checklists more easily. Modified versions of the pads and foams may be useful on Earth in helmets for motorcyclists, athletes, and others.

The major ingredient of a foam of this type can be either of two materials: a soft silicone rubber or Viton® (or equivalent) fluoropolymer. In the case of a fluoropolymer, the density of the foam is about 5 lb/ft^3 (about 80 kg/m^3), which is considerably less than the 12 lb/ft^3 (about 192 kg/m^3) of standard commercial Viton® foams. The density is reduced by replacing part of the Viton A (or equivalent) resin with Viton LM (or equivalent), decreasing the proportion of carbon-black filler, and using a greater proportion of blowing agent. The temperature-vs.-time schedule followed in molding and curing is also modified to obtain uniform cell size and good foam skin thickness at low density.

In the case of a silicone formulation, a soft silicone rubber is compounded with activators, cross-linking agents, and blowing agents. Increasing the amount of blowing agent decreases the density and hardness, while increasing the amount of both cross-linking and blowing agents decreases the postcuring shrinkage of the foam.

Whether fluoropolymer or silicone, the base rubber is banded and cut off several times on a two-roll rubber mill. The ingredients are added slowly to the milling rubber, one at a time, until the blend is uniform. The blowing agent, Celogen 130 (or equivalent), is added last to prevent activation of it during milling. The temperature of the blend is maintained below 140 °F (60 °C) by water-chilled nip rolls. When the ingredients are uniformly blended, a slab of uncured rubber is sheeted off the mill at a thickness slightly greater than 1/4 in. (0.635 cm).

A slab, typically 4 × 4 in. (about 10 × 10 cm), is cut from the sheet and pressed between flat plates at room temperature for 10 min at a pressure of 300 lb/in.^{2} (about 2.1 MPa) to produce a preform slightly over 1/4 in. thick. The preform is placed in a preheated mold and held at 350 °F (177 °C) for 15 min, then cooled with water to room temperature. The mold is opened and the preform pops out, expanded to four times its original volume.

This work was done by Frederic S. Dawn and Jean S. Alexander of **Johnson Space Center** *and Richard P. Tschirch and Paul M. Drennan of Arthur D. Little, Inc. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Materials category.*
MSC-22288

Water-Borne, Silicone-Based, Primerless Paints

These paints dry to form flexible anticorrosion coats.

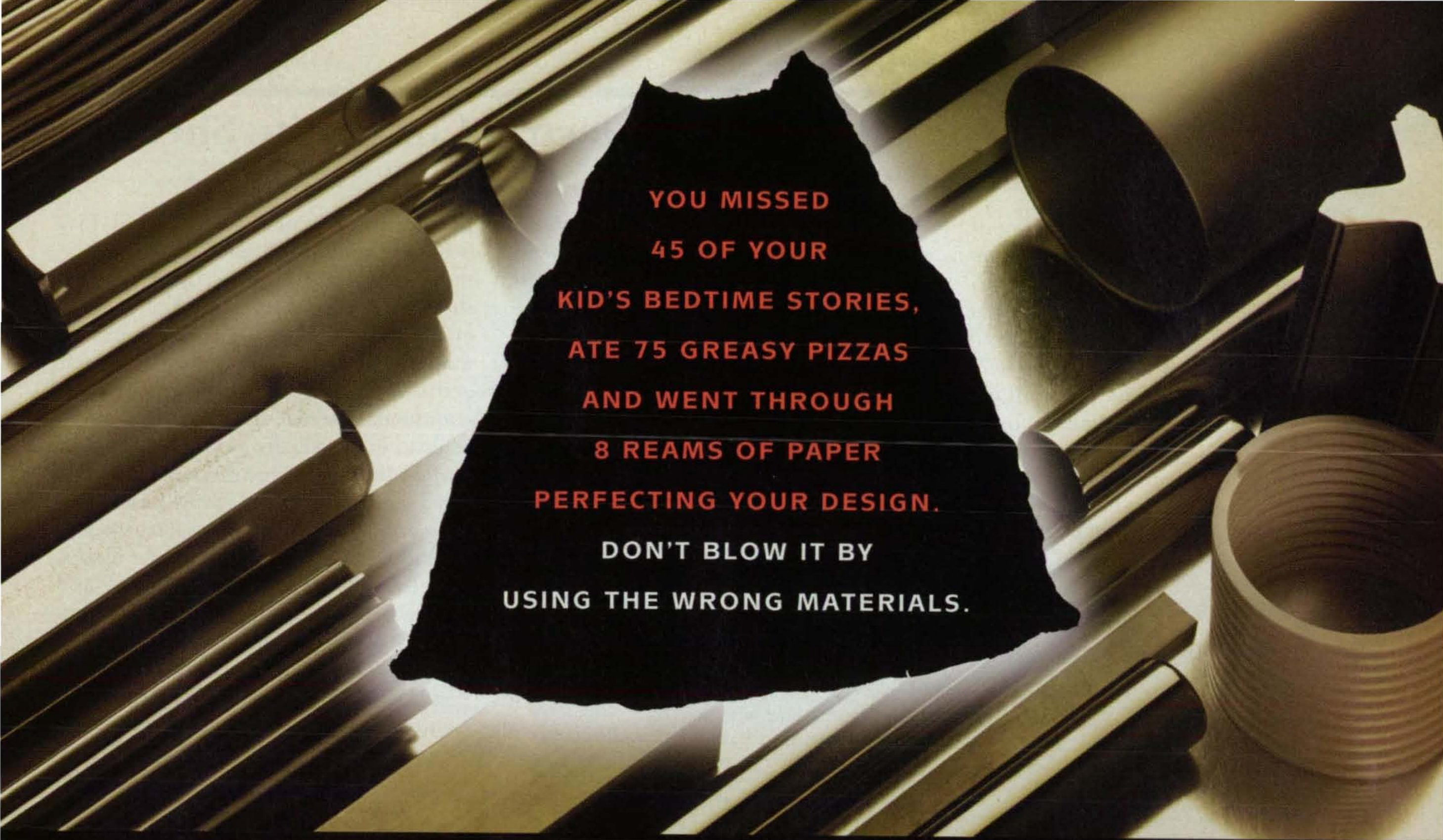
John F. Kennedy Space Center, Florida

Water-borne, silicone-based paints for protecting metal structures against corrosion have been developed as substitutes for traditional anticorrosion paints that contain large amounts of volatile organic solvents. It is desirable to reduce the volatile-organic-compound (VOC) contents of paints in order to reduce the associated pollution, toxicity, flammability, and problem of compliance with environmental regulations. The VOC contents of the present water-borne, silicone-based paints are less than 200 g/L. An additional desirable feature of these paints is that they can be applied without need for prior application of primers to ensure adhesion.

Paints of this type were formulated and tested for sprayability, dry-film adhesion, inhibition of corrosion, resistance to abrasion, flexibility, and resistance to weathering. Several formulations were found to continue to be effective in inhibiting corrosion on aluminum and stainless steel after 1,000 hours of corrosion exposure according to two American Society for Testing and Materials (ASTM) standard tests: ASTM B117 (a salt-spray test) and ASTM G85 (also known as the prohesion test — a test that involves cycles of alternate drying and spraying with a sulfate-rich solution).

In these tests, the water-borne, silicone-based paints performed as well as did flexible solvent-borne paints. The water-borne, silicone-based paints were found to be stable in that they exhibited shelf lives of more than one year. The drying time for these paints at ambient temperature is typically less than one hour. Coating films derived from optimized formulations of the water-borne, silicone-based paints were found to be flexible at temperatures down to –60 °C, to resist simulated outdoor weathering, and to protect metals against attack by acids. The best results were obtained with acrylic-latex/silicone emulsion blends formulated with low-toxicity corrosion inhibitors and extender pigments.

This work was done by Francis L. Keohan, Marcela Samsel, Melissa Perkins, Murty Bhamidipati, and Michael Goodwin of Cape Cod Research, Inc., for **Kennedy Space Center**. *For further information, contact the Kennedy Commercial Technology Office at 321-867-8130.*
KSC-12297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45 OF YOUR
KID'S BEDTIME STORIES,
ATE 75 GREASY PIZZAS
AND WENT THROUGH
8 REAMS OF PAPER
PERFECTING YOUR DESIGN.
DON'T BLOW IT BY
USING THE WRONG MATERIALS.

Computer Code for Analyzing Piezoelectric Composite Shells

John H. Glenn Research Center, Cleveland, Ohio

SMARTSHELL is a finite-element computer program for analyzing composite-material propulsion-system structural components (including shells) that are characterized as "smart" because they contain integral piezoelectric sensors and/or actuators. The program implements a unique mixed-field laminate theory, developed specifically for piezoelectric composite materials, that utilizes different approximations for response variables in such a manner as to (1) lead to greater accuracy than would otherwise be possible in predicting electric potentials and temperatures while (2) maintaining computational efficiency in determining displacement fields. SMARTSHELL accounts for the effects of thermal-expansion mismatch, pyroelectricity, and temperature-dependent properties of materials. SMARTSHELL is based on the principles of linear thermopiezoelectricity and accounts fully for the coupling of mechanical, electrical, and thermal responses of piezoelectric materials in both their sensory and their active aspects. The use of a curvilinear coordinate system to derive finite elements leads to the capability to model arbitrarily shaped two- and three-dimensional structures. As a result, SMARTSHELL can serve as a comprehensive structural-analysis software tool that offers capabilities for modeling the different shape, vibration, and damping responses of "smart" piezoelectric propulsion-system components.

This program was written by Ho-Jun Lee and Dimitris Saravanos of **Glenn Research Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Software category.*

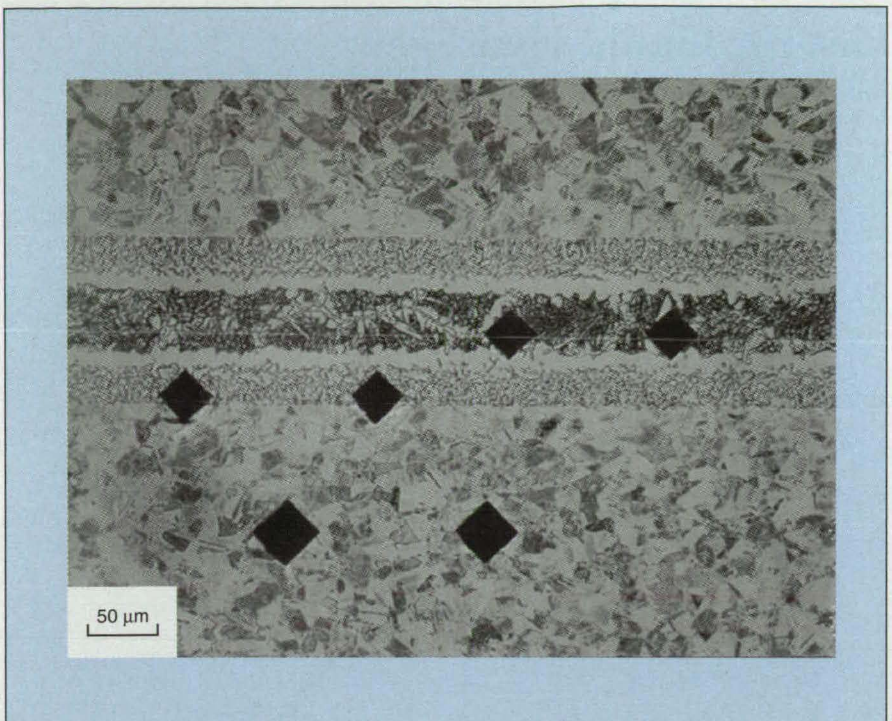
Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16854.

PM Gamma Titanium Aluminide and Fabrication Techniques

Lightweight, high-temperature-resistant parts can be manufactured economically.

John H. Glenn Research Center, Cleveland, Ohio

A γ titanium aluminide alloy produced by a powder-metal (PM) process, and techniques for fabricating sheets and sheet-metal components from the alloy, have been developed. The alloy and techniques, used together, are expected to satisfy a need for relatively economical manufacture of lightweight, high-temperature-resistant components of propulsion systems, control surfaces, and general structures of advanced aircraft and spacecraft. The specific strength of the alloy is similar to the spe-



A **Braze Joint** between two sheets of the PM Ti-46.5Al-4(Cr-Nb-Ta)-0.1B alloy was made by use of TiCuNi70 braze. The tilted black squares are marks left by a microhardness probe.

cific strengths of superalloys, while its specific stiffness is greater and its density is smaller. For applications in the temperature range of 500 to 800 °C, this alloy can be used in place of superalloys, thereby making it possible to reduce weights of components by as much as 50 percent.

The composition of the alloy is Ti-46.5Al-4(Cr-Nb-Ta)-0.1B. This is the same composition as that of an ingot-metal (IM) alloy used previously in a forging process. The manufacture of parts by the prior IM-based forging process was inhibited by (1) limitations, inherent in the process, on the sizes (including thicknesses) of sheets; (2) inconsistency of properties among sheets; and (3) high cost — ≈\$$10^4$/lb (≈\$$2.2 \times 10^4$/kg) [prices as of year 2000]. In contrast, it has been estimated that it will soon cost only ≈\$150/lb (≈\$330/kg) to manufacture parts by use of this PM alloy and the associated fabrication techniques. Even in comparison with other titanium alloys, the weights of components made of this alloy can be 15 percent lower.

The PM-based process can be summarized as follows:

1. A powder mixture of the required composition is consolidated into a pre-material blank. In the prior IM-based process, the consolidation step included hot isostatic forging and resulted in a 50-percent rejection rate. In contrast, the PM consolidation step results in a nearly zero rejection rate.
2. The top and bottom of the blank are machined parallel.
3. The blank is canned, rolled, and decanned.
4. The blank is ground to final thickness.

One of the techniques developed in conjunction with this alloy and the aforementioned process is a sheet-rolling technique that makes it possible to produce sheets of the alloy at relatively low cost. Another technique is one of relatively-low-temperature hot forming that eliminates (relative to a prior hot-forming technique) the need for hot presses in environmental chambers. Also developed were innovative brazing (see figure), transient-liquid-phase bonding, and laser welding techniques. The combination of these developments makes it possible to fabricate components ranging from turbine blades 1 in. (≈2.5 cm) long to hot propulsion-system ducts as long as 30 ft (≈9 m).

This work was done by Paul Bartolotta of **Glenn Research Center**, *Gopal Das of Pratt & Whitney, Heinrich Kestler of Plansee Aktiengesellschaft, and Rob LeHolm of B. F. Goodrich Co. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Materials category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-17173.

Composite-Material Pipes for Liquid Hydrogen

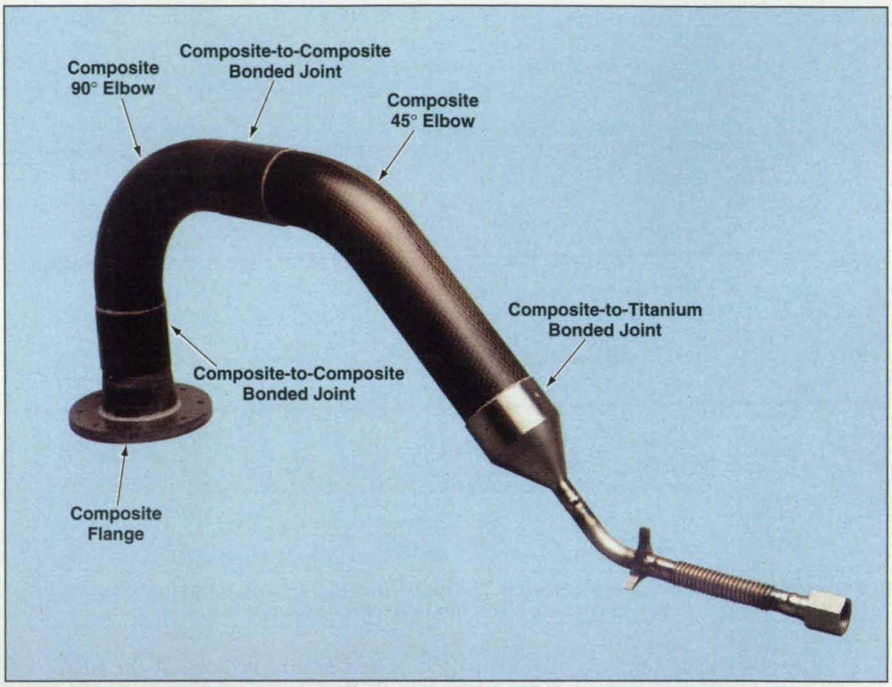
Weight is saved by eliminating metal components.

Marshall Space Flight Center, Alabama

Pipes made of graphite-fiber/epoxy-matrix composites have been shown to be suitable as conduits for liquid hydrogen. Conceived for as replacements for heavier metallic liquid-hydrogen feedlines in spacecraft, pipes like these could also be advantageous in terrestrial applications in which there are requirements to minimize weights.

Heretofore, feedlines for cryogenic applications have been fabricated from conventional metals. The present pipes are fabricated from composite materials. These composite pipes are also fabricated without metal flanges or other metal end fittings. Elimination of the metal components reduces weight.

The figure depicts an all-composite-material spacecraft liquid-hydrogen feedline that was constructed and tested. The design of this feedline incorporated five features that would have to be proven to demonstrate practicality. These features and their rationale were the following:



The **Prototype Composite-Material Feedline** was designed with five features that were considered essential to a demonstration of feasibility.

- *No Metal Liner* — While the absence of a metal liner made the feedline weigh less than it otherwise would, it raised a concern over potential leakage. However, no leakage was observed in ground or flight tests.
- *Composite-Material 45° and 90° Elbows* — It was necessary to demonstrate the manufacture and use of composite-material elbows because feedlines are often routed along twisting three-dimensional paths, making it essential to include elbows.
- *Composite-Material Flanges* — A metallic feedline typically consists of a pipe with a flange at each end. The flanges are often the heaviest components of metallic feedlines. Hence, the use of composite material flanges in addition to a composite tubular section saves considerable weight.
- *Joint Between Two Composite-Material Tube Sections* — Some feedlines can be so long or have such a complex geometry that they cannot be fabricated as single pieces. It is necessary to fabricate them by joining shorter feedlines end to end. The inclusion of a joint between two composite-material tube sections demonstrates the practicality of this approach to the fabrication of long or complex shaped composite-material feedlines.
- *Joint Between a Composite-Material and a Metallic Tube* — In a typical cryogenic system, there is at least one location where a feedline must be joined to a metal component (e.g., a bellows). Such joining was demonstrated in the prototype by including an adhesive bond between the composite-material pipe and a titanium end fitting.

This work was done by Philip Tygielski of **Marshall Space Flight Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Materials category.*
MFS-31632

Refractory, Oxidation-Resistant Ceramic/Carbon Insulation

These materials can withstand temperatures up 1,700 °C.

Ames Research Center, Moffett Field, California

Lightweight, refractory ceramic/carbon thermal-insulation materials have been invented. These materials, consist of carbon, silicon, and oxygen in suitable proportions combined into molecular structures that are stable at high temperatures. Insulating tiles and other components made of these materials can retain their shapes and strengths at temperatures as high as 1,700 °C.

The production of a component of this type begins with the fabrication of a substrate (preform) of porous carbon (e.g., carbon felt or tile). This substrate serves as the source of carbon for the ceramic/carbon material to be formed. The carbon substrate also serves as a framework that supports the other materials to be added (as described below) to the carbon to form the ceramic/carbon material and, hence, defines the size and shape of the component to be formed.

A sol-gel containing dialkoxy and trialkoxy silanes (and possibly tetralkoxy

silanes, depending on the application) plus an alcohol and water is prepared, and gelling is initiated by adding an acid or base to the sol-gel. Before significant gelling occurs, the carbon substrate is impregnated by immersion in, or coating with, the sol-gel. Once impregnation has occurred, gelation is allowed to proceed. Gelation can occur at ambient temperature, but is preferably accelerated by heating to a temperature between 40 and 90 °C. Once gelation is complete, the excess gel is removed from the impregnated substrate, then the impregnated substrate is dried in a vacuum — typically overnight at a temperature between 70 and 100 °C — to remove volatiles. The dried ceramic substrate thus becomes a ceramic precursor.

The ceramic is formed by pyrolyzing the dried, gel-impregnated substrate in a vacuum or an inert gas (e.g., argon) at temperatures that can range from 800 to 1,500 °C. The carbon of the substrate enters into the pyrolysis reaction with the dried gel, thereby becoming part of the ceramic. The ceramic pyrolysis product contains –Si–C–Si– and –Si–O–C– bonds. The excess of C provided by the carbon substrate results in a predominance of –Si–C–Si bonds: this is fortunate because at high temperature, the –Si–C–Si– bonds are more stable than are the Si–O–C– bonds.

The substrate can be subjected to multiple cycles of impregnation, drying, and pyrolysis. Each cycle adds to the weight, strength, and high-temperature endurance of the finished product. Hence, one chooses the number of cycles in a tradeoff between light weight on the one hand and strength and high-temperature endurance on the other hand.

This work was done by Daniel B. Leiser of **Ames Research Center** *and Ming-ta S. Hsu and Timothy S. Chen of HC Chem Research. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Materials category.*

This invention has been patented by NASA (U.S. Patent No. 6,225,248). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Ames Research Center, (650) 604-5104. Refer to ARC-14202.

Analyzing Loads and Strains in Polymer-Matrix Composites

John H. Glenn Research Center, Cleveland, Ohio

Strain Rate Dependent Analysis of Polymer Matrix Composites (STRANAL-PMC) is a computer program for analyzing strain-rate-dependent, nonlinear deformation and failure responses of composite materials in which the matrices are ductile polymers. Modified versions of the Ramaswamy-Stouffer constitutive equations of viscoplasticity, originally developed for metals, are used to represent deformation of a polymeric matrix. The equations are applied in a micromechanical approach, in which each unit cell is divided into several slices. Appropriate uniform stress and uniform strain assumptions, along with the constitutive equations for the fiber and matrix, are used to compute the response of the slice. Laminate theory is then applied to obtain the effective response of a ply, and is applied again to obtain the effective response of a multilayered composite laminate. To predict the ultimate strength of each composite ply, the Hashin failure criteria are implemented within the micromechanics. The constitutive equations are integrated in time by a Runge-Kutta technique. The inputs to STRANAL-PMC are the geometry of the composite laminate, the properties of the fiber and matrix materials, and the applied stress or strain versus time. The outputs of STRANAL-PMC are the stress and strain at the slice, ply, and laminate levels at each time step.

This program was written by Robert K. Goldberg of **Glenn Research Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Software category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-17227.

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Electronic Components and Systems

Synthesis of Fuzzy-Logic Circuits in Evolvable Hardware

Evolution in hardware can overcome the difficulty of designing by conventional methods.

NASA's Jet Propulsion Laboratory, Pasadena, California

The synthesis of some fuzzy-logic circuits by use of evolvable hardware (EHW) has been demonstrated in an investigation of EHW as a means of automated synthesis of computational-intelligence circuitry in general. This investigation is, in turn, part of continuing research on the broader topic of EHW as the basis of a general method of automated design and/or automated direct synthesis of electronic circuits that can perform acceptably close approximations of any desired analog and/or digital functions.

The basic concepts and some specific implementations of EHW were described in several previous *NASA Tech Briefs* articles, namely: "Reconfigurable Arrays of Transistors for Evolvable Hardware" (NPO-20078), Vol. 25, No. 2 (February 2001), page 36; "Evolutionary Automated Synthesis of Electronic Circuits" (NPO-20535), Vol. 26, No. 7 (July 2002), page 33; "Designing Reconfigurable Antennas Through Hardware Evolution" (NPO-20666), Vol. 26, No. 7 (July 2002), page 34; "'Morphing' in Evolutionary Synthesis of Electronic Circuits" (NPO-20837), Vol. 26, No. 8 (August 2002), page 31; and "Mixtrinsic Evolutionary Synthesis of Electronic Circuits" (NPO-20773), Vol. 26, No. 8 (August 2002), page 32.

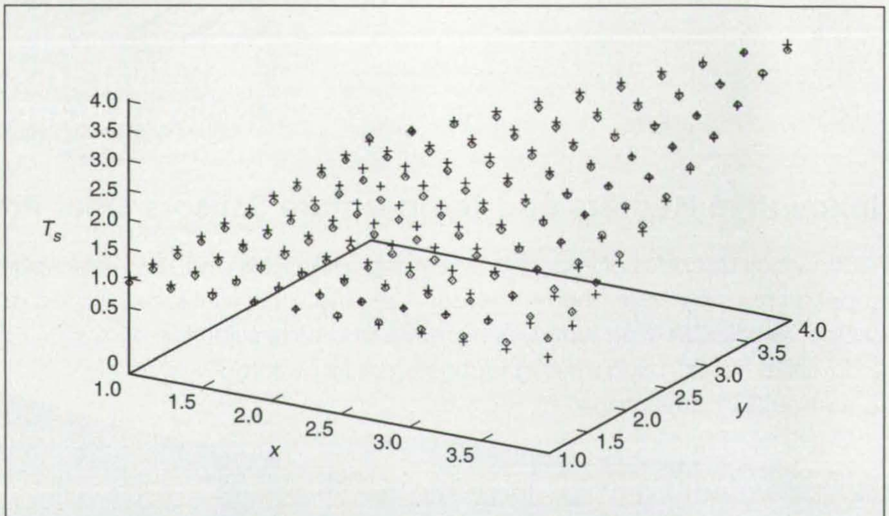
To recapitulate from the cited prior articles: "Evolution" and "evolvable" as applied to EHW are meant in a quasi-genetic sense, referring to the construction and testing of a sequence of populations of circuits that function as incrementally better solutions of a given design problem. Evolution is effected through the selective, repetitive connection and/or disconnection of transistors, amplifiers, inverters, and/or other circuit building blocks. The evolution is guided by a search-and-optimization algorithm (in particular, a genetic algorithm) that operates in the space of possible circuits to find a circuit that exhibits the desired behavior. If evolved circuits are tested by mathematical modeling (that is, computational simulation) only, the evolution is said to be extrinsic; if they are tested in real hardware, the evolution is said to be intrinsic; if they are tested in random sequences of computational simulation and real hardware, the evolution is said to be mixtrinsic.

For the synthesis of fuzzy-logic circuitry following the present approach, the hardware portion of an EHW system is a field-programmable transistor array (FPTA) — a very-large-scale integrated (VLSI) circuit that contains electronically reconfigurable cellular arrays of transistors (optionally also including resistors and capacitors). "Electronically reconfigurable" signifies that the electrical connections among elements of an array are made and broken by use of transistor switches that are commanded to open or close, respectively, by control bit strings generated by an evolutionary algorithm. EHW is especially attractive as a potential means of synthesizing combinatorial fuzzy-logic circuits because it is very difficult to synthesize such circuits by conventional design methods. When fuzzy logic is implemented in electronically reconfigurable circuitry, there is an additional advantage of flexibility to change the circuitry in the event that a need for changed fuzzy logic arises during operation.

The fuzzy-logic operators considered thus far in the investigation are of a subtype of the type known in the art as triangular norms and conorms. The triangular norms and conorms are used in fuzzy logic to represent conjunctions (roughly the equivalent of AND operators) and disjunctions (roughly the equivalent of OR operators). A triangular norm or conorm of the particular subtype considered is a function of two input signals (x and y) and a parameter (s). In the case $s = 0$, this particular triangular norm or conorm is a minimum or maximum function (equal to x or y, which is smaller or larger, respectively); in cases of $s \neq 0$, this triangular norm and conorm are more complex functions of x and y. The figure depicts the response of a circuit that was evolved directly in hardware on a FPTA chip for the case $s = 100$, for which the triangular norm is given by

$$S_s(x,y) = 1 - \log_s\left[1 + \frac{(s^{1-x}-1)(s^{1-y}-1)}{s-1}\right].$$

This work was done by Adrian Stoica of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Electronic Components and Systems category.*
NPO-21095



The **Actual Response** (indicated by "◊" data points) of a circuit evolved to implement the fundamental triangular norm for $s = 100$ is plotted along with the desired response $S_s(x,y)$ (indicated by "+" data points).

Improved Circularly Polarized Microstrip Antenna

Lyndon B. Johnson Space Center, Houston, Texas

Two modifications improve the performance of a circularly polarized microstrip-patch-array antenna described in U.S. Patent 5,661,994. Because the phase difference between the orthogonal sides in the original design was 135°, there was substantial cross-polarization and waste of power. One modification is a change in the layout of two microstrip transmission lines through which excitation is applied to two orthogonal sides of each microstrip patch, such that the phase difference between the sides becomes 90°, which is optimum for circular polarization. The other modification pertains to the use of a quarter-wave impedance transformer after a junction that sums the power of two elements of a two-element subarray. When combining these subarrays to form a four-element subarray, the use of a post-junction transformer dictated the use of a meandering transmission line to obtain the required phase shift between the subarrays. The second modification is the placement of an impedance transformer before the junction, such that a transformer is no longer needed after the junction and the meandering transmission line can be eliminated. Hence, the radiative, ohmic, and dielectric losses of the meandering transmission line are also eliminated and the design is simplified.

This work was done by Patrick Fink of **Johnson Space Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Electronic Components and Systems category.*

This invention has been patented by NASA (U.S. Patent No. 6,288,677). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center, (281) 483-0837. Refer to MSC-23089.

Direct Methanol Fuel Cells for Low-Power Applications

Fuel-cell stacks would be integrated with refillable reservoirs.

NASA's Jet Propulsion Laboratory, Pasadena, California

Direct methanol fuel cells integrated with fuel reservoirs have been proposed as power sources in applications that involve power demands up to about 50 W. A prior concept of direct methanol fuel cells as alternatives to rechargeable batteries in such applications was reported previously in "Miniature Fuel Cells for Small, Portable Electronic Devices" (NPO-21066), *NASA Tech Briefs*, Vol. 26, No. 8 (August 2002), page 30. The prior concept called for the fuel (a methanol/water solution) to be supplied from reservoirs outside the fuel cells. The present concept would eliminate the need for separate reservoirs, thereby reducing bulk and complexity and increasing convenience of use.

A fuel-cell assembly according to the present proposal would include a stack of fuel cells either above or surrounded by a fuel reservoir, all contained within a single housing. Wicks would protrude

from the anodes in the stack into the reservoir. The wicks would deliver the methanol/water fuel solution to the anodes by capillary action. Oxygen in the air would be accessible to the cathodes.

The water produced in the fuel-cell chemical reactions could be discharged as a liquid into the reservoir to maintain the required relative concentrations of water and methanol; alternatively, this water could be emitted as a gas along with carbon dioxide, which is also produced in the fuel-cell chemical reactions. Refueling could be accomplished by injecting or pouring additional methanol or methanol/water solution into the reservoir from a syringe, a container similar to a cigarette-lighter-fuel container, or other suitable vessel.

This work was done by Gerald Halpert, Harvey Frank, and Sekharipuram Narayanan of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Electronic Components and Systems category.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

Intellectual Assets Office
JPL
Mail Stop 202-233
4800 Oak Grove Drive
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Refer to NPO-30331, volume and number of this NASA Tech Briefs *issue, and the page number.*

Lithium-Ion Batteries for Demanding Applications

These power sources feature high capacities and long lifetimes.

Lyndon B. Johnson Space Center, Houston, Texas

High-performance lithium-ion electrochemical cells and batteries have been developed to satisfy a need for longer lifetimes and greater capacities in the power supplies of the life-support systems attached to space suits. These and similar cells and batteries could also be used on Earth to satisfy requirements for high energy densities, high power levels, and long lifetimes in a variety of applications, including electric vehicles, medical electronic equipment, communication equipment, uninterruptible power supplies, and power tools.

One prototype battery, rated at a nominal power of 900 W, was assembled from five prismatic cells dimensioned to fit the space-suit battery compartment. The battery can be discharged at any temperature between –40 °C and +55 °C. Each cell is rated at a nominal discharge capacity of 45 Ah. Each cell was found to be capable of delivering a charge of 47 Ah while maintaining a voltage of at least 2.5 V, or delivering a charge of 45 Ah at a current of 5 A while maintaining a voltage of at least 3.2 V. These cells have been designed to enable the fabrication of a space-suit battery that weighs less than does the present silver/zinc space-suit battery while offering a capacity, rate capability, and lifetime greater than those of the present battery, which is rated at a capacity of 29.5 Ah and a "wet" lifetime of 425 days.

At a current of 2.5 A, these cells are characterized by a mass-specific energy density of 158 Wh/kg and a volumetric energy density of 377 Wh/L. They have been demonstrated to be capable of sustaining a continuous current of 80 A while delivering a charge of 35 Ah, as well as a capability for pulse discharge at a current of 250 A.

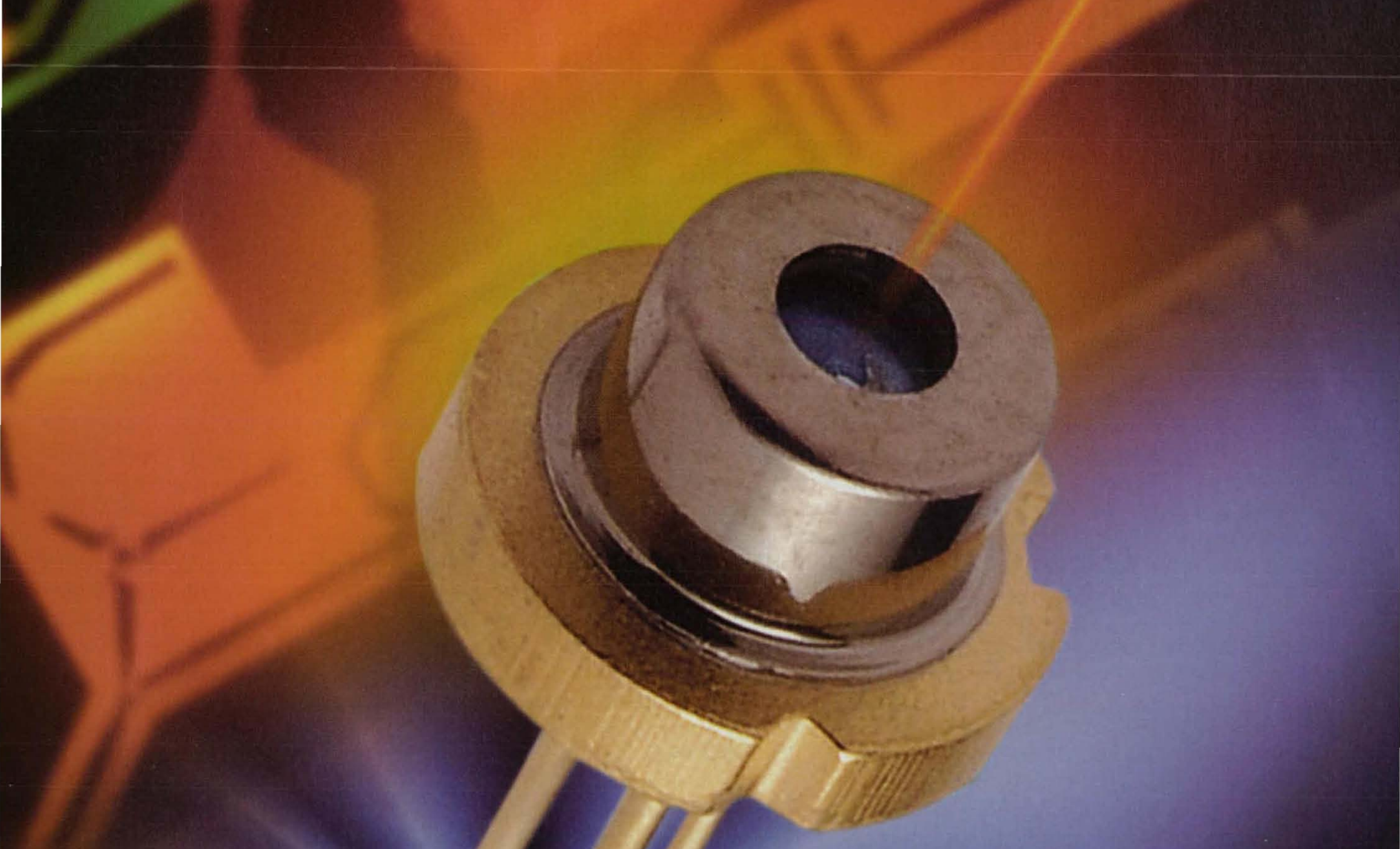
The prismatic cell is protected by a thick-walled stainless-steel case that affords protection against crushing and puncturing. The five-cell battery weighs 12.3 lb (has a mass of 5.6 kg) — 2 lb (0.9 kg) less than does an advanced silver/zinc space-suit battery. At a discharge current of 3.8 A, this battery was found to deliver 47 Ah at a voltage above 16 V; in so doing, it exhibited 59 percent more capacity than the 29.5 Ah capacity specified for the present silver/zinc battery. This greater capacity could support a mission as long as 12 hours. In addition, whereas the silver-zinc battery exhibits short "wet" life and large capacity fade, the present Li-ion battery retains a significantly greater fraction of its initial capacity for a longer time.

This work was done by Grant M. Ehrich and Michael J. Hetzel of Yardney Technical Products Inc. for **Johnson Space Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Electronic Components and Systems category.*
MSC-23285

November 2002

PHOTONICS Tech Briefs

PHOTONICS SOLUTIONS FOR THE DESIGN ENGINEER



Cover photo courtesy of Photonic Products Ltd., see page 14a.

www.ptbmagazine.com

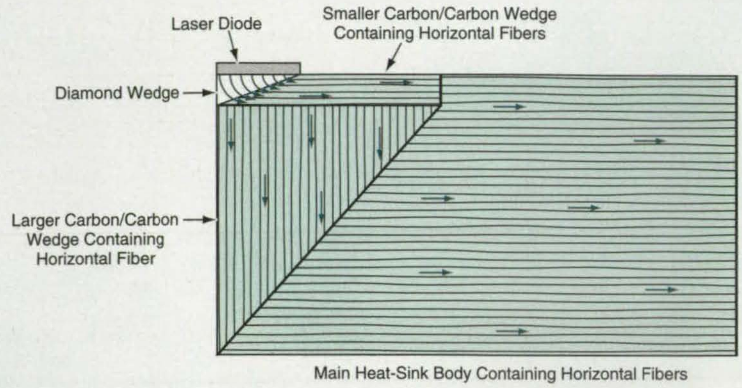
Carbon-Composite Heat-Sinking Submounts for Laser Diodes

Thermal and mechanical properties can be tailored.

Langley Research Center, Hampton, Virginia

Carbon-composite submounts tipped with diamond are being developed as improved means of dissipating heat generated in high-power laser diodes. Copper is the traditional heat-sinking material for many applications other than laser diodes; it is not suitable for heat-sinking submounts for laser diodes because its coefficient of thermal expansion (CTE) is too high to enable an acceptably close match to the CTEs of laser-diode semiconductor materials. Heretofore, heat-sinking submounts for laser diodes have been made from a copper/tungsten alloy, chosen because of its rigidity and its low CTE, which matches the CTEs of the laser-diode semiconductor materials more closely than copper does. Unfortunately, the thermal conductivity of the copper/tungsten alloy is only 45 percent of that of copper. In contrast, the carbon composites of the present development can be made to have both low CTEs and effective thermal conductivities of the order of three times that of copper.

The carbon-composite materials under consideration in the present development effort include, variously, graphitic or vapor-grown carbon fibers in matrices that comprise one or more other forms of carbon and that can include diamondlike carbon. Metals (typically, copper or aluminum) can be used as alternative matrix materials to increase effective thermal conductivities. Like other composite materials, these composites can be formulated to tailor their thermal and mechanical properties within the limits imposed by the intrinsic properties of the constituent materials.



The **Diamond and Carbon/Carbon Composite Parts** of this submount are designed to exploit the high thermal conductivities along vertical and horizontal fibers to conduct heat efficiently from the laser diode into the main heat-sink body.

The thermal conductivities of these composites are much higher in the along-fiber directions than in the cross-fiber directions. This anisotropy must be taken into account in designing a heat-sinking submount, as in the example illustrated in the figure. The laser diode is mounted on a wedge made of either chemical-vapor-deposited diamond (which has about twice the thermal conductivity of copper) or single-crystal diamond (which has about five times the thermal conductivity of copper). The diamond wedge conducts heat away from the laser diode. The slanted face of the diamond wedge distributes some of the heat to a mating carbon/carbon composite wedge that contains horizontal fibers and that conducts this portion of the heat into a main carbon/carbon heat-sink body that also contains horizontal fibers. The slanted face of the diamond wedge also distributes some of the heat downward into a larger carbon/carbon composite wedge that contains vertical fibers. These vertical fibers meet the horizontal fibers of the main heat-sink body at mating slanted wedge surfaces. The heat-sink body conducts the heat away horizontally. The far end (the right end in the figure) of the heat-sink body is placed in contact with a heat pipe, radiator panel, or other suitable heat sink.

This work was done by Sang Hyouk Choi and Howard G. Maahs of **Langley Research Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Materials category.*
LAR-15949

Thermography Using $YVO_4:Dy^{3+}$

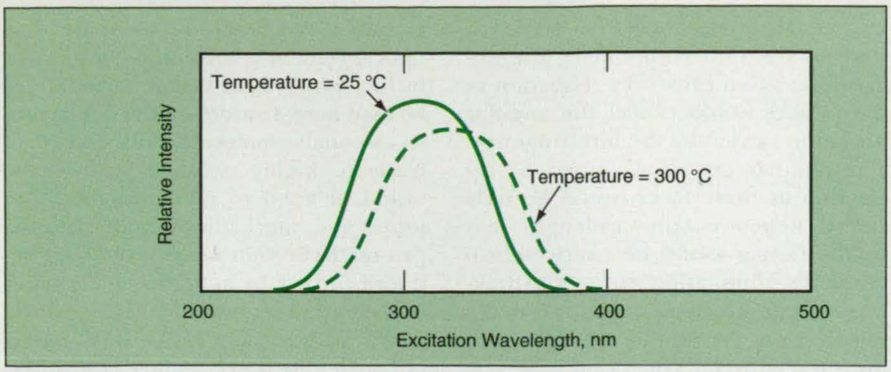
$YVO_4:Dy^{3+}$ has unique florescence characteristics that appear to be suited to thermography.

Langley Research Center, Hampton, Virginia

A proposed thermographic technique would exploit the unique fluorescence characteristics of yttrium vanadate doped with dysprosium ($YVO_4:Dy^{3+}$). The particular aspect of the fluorescence characteristics that would be exploited in this technique is the relative intensity of emitted light as a function of the temperature and of the wavelength of the light used to excite the fluorescence (see figure).

An object to be thermographed would be coated with $YVO_4:Dy^{3+}$ and would be imaged by use of a high-speed framing camera with timing circuitry that could be used to obtain exposure times shorter than 1 µs. The $YVO_4:Dy^{3+}$-coated surface would be illuminated in succession by two laser pulses: one at a wavelength between 275 and 310 nm, the other at a wavelength between 340 and 355 nm. The first-mentioned wavelength band contains the peaks of the curves shown in the figure and is the spectral region wherein the relative intensity of emitted light decreases with increasing temperature. In the second-mentioned wavelength band, the relative intensity of emitted light increases with increasing temperature.

The operation of the camera and lasers would be synchronized, with suitable triggering delays. The camera would be made to acquire an image a few tens of mi-



The **Relative Intensity of Fluorescence** of $YVO_4:Dy^{3+}$ varies with both temperature and the excitation wavelength. The intensity decreases with temperature in the peak region but increases with temperature in the foot region at the long-wavelength end.

croseconds after the laser pulse (allowing for fluorescence rise time) at the first wavelength. This image would be digitized. Then, similarly, the camera would be made to acquire an image after the laser pulse at the second wavelength and that image would also be digitized. To make it possible to distinguish between fluorescence excited by the two laser pulses, the delay between the pulses would be made a multiple (or at least a significant fraction) of the fluorescence decay time (which is of the order of 160 μs or less).

The data from digitization of the images would be processed to extract the temperature of each pixel from the relative intensities for that pixel in the two images. The processing would involve inversion of the excitation-wavelength and temperature dependences.

This work was done by Gregory M. Buck of **Langley Research Center**. *For further information, contact the Langley Commercial Technology Office at (757) 864-6005.*
LAR-15067

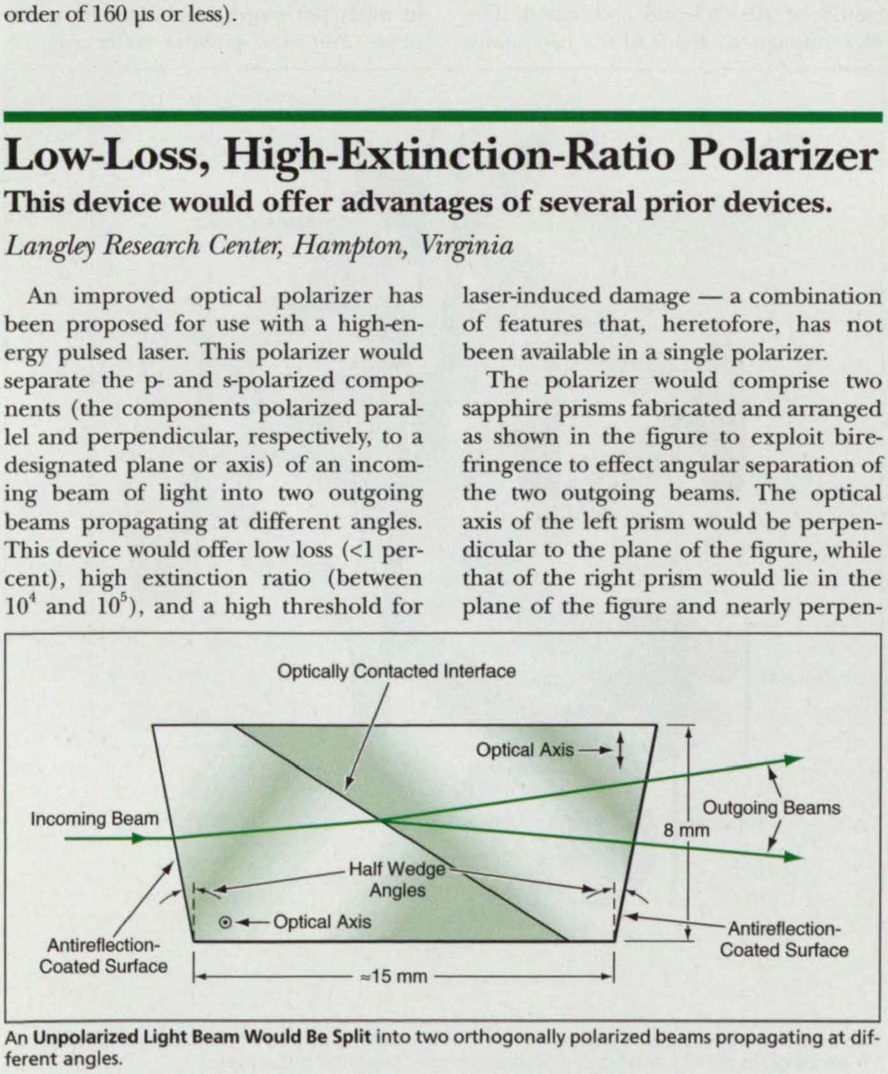
Low-Loss, High-Extinction-Ratio Polarizer

This device would offer advantages of several prior devices.

Langley Research Center, Hampton, Virginia

An improved optical polarizer has been proposed for use with a high-energy pulsed laser. This polarizer would separate the p- and s-polarized components (the components polarized parallel and perpendicular, respectively, to a designated plane or axis) of an incoming beam of light into two outgoing beams propagating at different angles. This device would offer low loss (<1 percent), high extinction ratio (between 10^4 and 10^5), and a high threshold for laser-induced damage — a combination of features that, heretofore, has not been available in a single polarizer.

The polarizer would comprise two sapphire prisms fabricated and arranged as shown in the figure to exploit birefringence to effect angular separation of the two outgoing beams. The optical axis of the left prism would be perpendicular to the plane of the figure, while that of the right prism would lie in the plane of the figure and nearly perpen-



An **Unpolarized Light Beam Would Be Split** into two orthogonally polarized beams propagating at different angles.

dicular to the direction of the incoming beam. As a result of the birefringence of sapphire and the different orientations of the optical axes of the two prisms, the different polarization components of the incident light beam would be refracted to different angles at the diagonal interface between the prisms.

In a typical application, it is required to have one of the outgoing beams undeviated (that is parallel to the incoming beam). To satisfy this requirement, the prisms would be wedged: that is, the entrance and exit faces would not be parallel to each other and, instead, would be slanted by a small angle chosen so that, for one polarization component, the angular deviation caused by refraction at these faces would cancel the angular deviation caused by the birefringence. The angular deviation caused by refraction at these faces would be only slightly dependent on wavelength: that is, the device would be nearly achromatic. By eliminating surfaces orthogonal to the incoming beam, the wedging of the prism would also minimize optical feedback to the laser.

In other, similar prism assemblies, it is common practice to minimize reflection losses at the mating surfaces of the two prisms by use of optical cement. Because optical cement is susceptible to damage by high-power laser beams, it would not be used here: Instead, optical contacting — essentially, molecular adhesion of ultraclean, highly polished surfaces — would be used to minimize reflection losses and mechanically join the two prisms. Reflection losses would be reduced further by antireflection coating of the entrance and exit faces.

This work was done by Norman P. Barnes of **Langley Research Center**. *For further information, contact the Langley Commercial Technology Office at (757) 864-6005.*
LAR-15636

Simplified Achromatic Nulling Beam Combiner

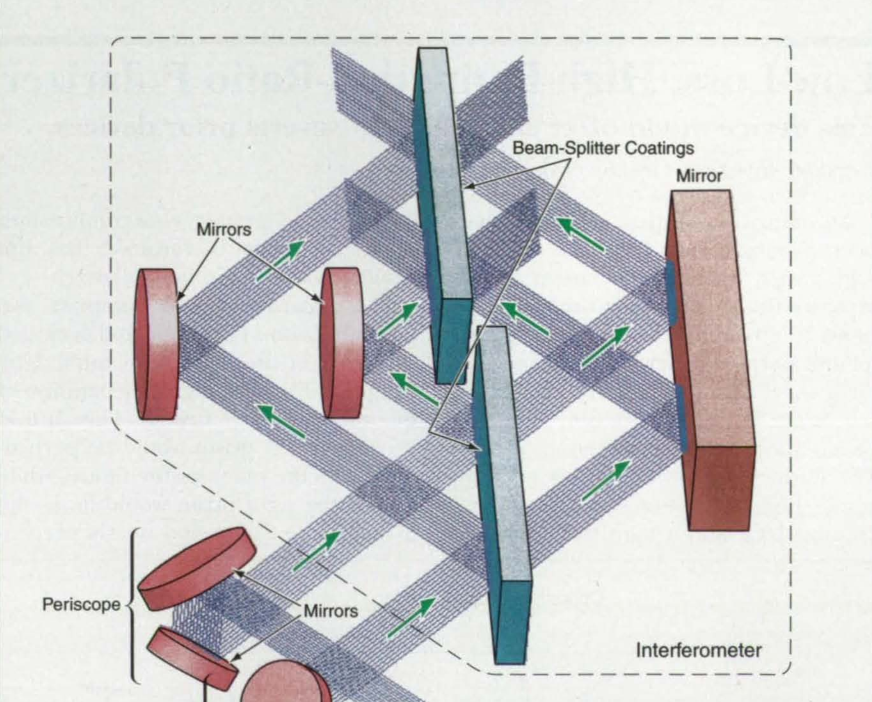
A compact, symmetric optical train consists entirely of flat optics.

NASA's Jet Propulsion Laboratory, Pasadena, California

The figure schematically depicts a proposed achromatic nulling beam combiner. This instrument is intended for use in astronomy — principally, for attenuating light from stars or other bright sources in order to enable detection of fainter objects that lie near the bright sources. In comparison with a prior nulling beam combiner, the proposed instrument would be simpler, made of fewer parts, easier to use, and less sensitive to the details of optical coatings. The proposed design provides for rigorous symmetry of the optical train. Moreover, the simplified design involves a relatively compact, mostly planar, configuration based entirely on flat optics, with fewer reflections than in previous designs. Because of its high degree of symmetry, the instrument would be inherently achromatic (broad-band) and capable of processing dual polarization light.

The impetus for the proposed design was the idea that unlike prior approaches, it should be possible to separate the field-flipping and the beam-combining stages. If a relative field inversion were accomplished first, subsequent superposition of the two input beams in a standard interferometer would yield subtraction rather than addition of the electromagnetic fields of the beams at zero optical path difference. In addition, it was realized that if, unlike in prior designs, the optical train could be made completely symmetric, it would theoretically be possible to subtract two identical input beams perfectly (neglecting such practical limitations as variations of optical coatings and errors of alignment and phasing).

It is assumed that the two input beams would be parallel and collimated. The electromagnetic fields of the two beams would be flipped, relative to each other, by reflection in two mirror-symmetric right-angle periscopes. The two mirrors in each periscope would effect one s-plane and one p-plane reflection, re-



Two Inverted, Right-Angle Periscopes and an Interferometer based on a Mach-Zehnder interferometer would perform field-flipping and beam-combining functions, respectively.

spectively, and together they would reverse the roles of the s-plane and p-plane reflections. Hence, the two polarization states would be affected symmetrically by each periscope and hence, as long as the coatings on the mirrors in both periscopes were identical, no s-p phase delay would be incurred. After passage through these periscopes, the propagating two-polarization-component fields should be identical to the input fields, except for the relative field flip.

The beam-combining stage would be based on a Mach-Zehnder interferometer in which each beam would encounter two beam splitters. With respect to the transmission and reflection coefficients for the two polarization states, the encounter with each beam splitter would be reciprocal to the encounter with the other beam splitter, so that complete symmetry would be ensured.

This work was done by Eugene Serabyn and Mark Colavita of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Physical Sciences category.*
NPO-21156

Miniature, Feedback-Stabilized, Broad-Band Light Sources

Sizes, weights, power levels, and stabilization times would be reduced.

NASA's Jet Propulsion Laboratory, Pasadena, California

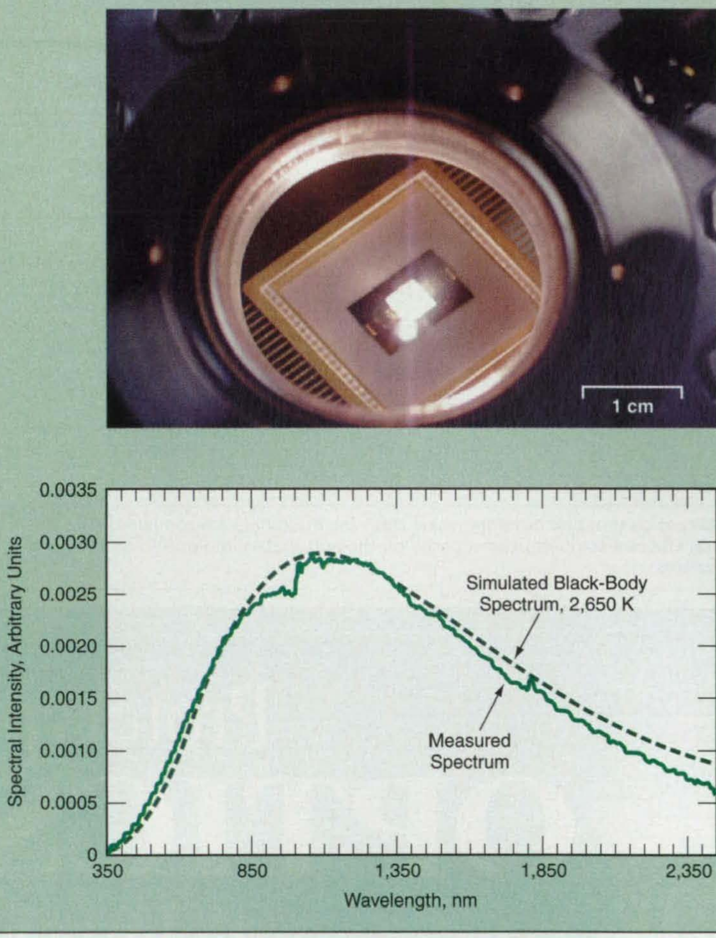
Miniature, feedback-stabilized sources of broad-band light are under development for use in the illumination and calibration of imaging spectrometers and other optoelectronic scientific instruments. These sources would be designed and fabricated by use of techniques developed for semiconductor integrated circuits and extended to microelectromechanical systems (MEMS). In the original intended application, a device of this type would supplant the onboard calibrator (OBC) in NASA's airborne vis-

Parameter	Developmental OBC	Current OBC
Volume	≈ 30 cm^3	≈ 15,000 cm^3
Mass	≈ 50 g	≈ 2,000 g
Power Consumption	≈ 2 W	≈ 30 W

Key Parameters of current and developmental OBCs for the AVIRIS are compared. The values for the developmental OBC are estimates based partly on the anticipated integration of all optical and electronic components.

ible/infrared imaging spectrometer (AVIRIS).

Conventional OBCs contain off-the-shelf light bulbs and discrete electronic and optical components. In contrast, the developmental light sources have the potential to be smaller, less massive, and less power-hungry by several orders of magnitude (see table). The developmental light sources would be microfabricated out of silicon in predominantly planar geometries like those of typical integrated circuits; consequently, it would be relatively easy to integrate the light sources with silicon-based electronic drive circuitry and with optical fibers. In comparison with conventional OBCs, the developmental light sources would be relatively insensitive to fluctuations in temperature. Moreover, because they would be less massive, they would operate with shorter stabilization times.



A **Proof-of-Principle Demonstration** of a micromachined incandescent lamp was conducted in a vacuum chamber. The measured spectrum of light emitted from the tungsten filament of the lamp approximated a black-body spectrum for a temperature of 2,650 K.

A device of the type under development would be a fully integrated, monolithic optoelectronic system that would include a micromachined incandescent lamp, a fiber-optic output coupler, and an infrared photodetector and associated electronic circuitry for negative-feedback stabilization of the current supplied to (and thus the brightness and temperature of) the lamp. Micromachined incandescent lamps like those that would be incorporated into these devices were described in "Micromachined Broad Band Light Sources" (NPO-20655), *NASA Tech Briefs*, Vol. 25, No. 4 (April 2001), page 44. A prototype that included only a lamp has been demonstrated (see figure). Integration of a lamp with a photodetector and feedback circuitry is a goal of proposed development efforts for the near future.

This work was done by Thomas George, Eric Jones, Michael Eastwood, Margaret Tuma, and Richard Hansler of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Electronic Components and Systems category.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

Intellectual Property group
JPL
Mail Stop 202-233
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-2240

Refer to NPO-20935, volume and number of this NASA Tech Briefs *issue, and the page number.*

Semiconductor Quantum Dots as Radiation-Hard Light Emitters

Relative to p/n-junction LEDs, quantum dots tolerate ≈10^3 times as much radiation.

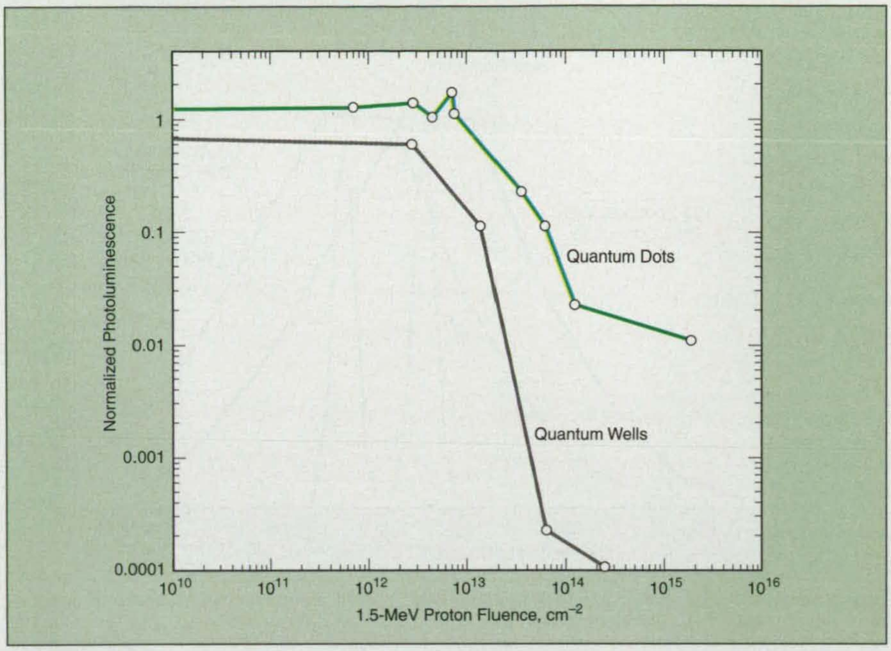
NASA's Jet Propulsion Laboratory, Pasadena, California

Light-emitting devices based on semiconductor quantum dots have been shown to be suitable for use in environments that include high levels of radiation that causes displacement damage in semiconductors — in particular, energetic protons. Conventional light-emitting diodes and other conventional optoelectronic devices become degraded rapidly by such radiation, giving rise to a need for radiation-hard devices. A preliminary confirmation of the feasibility of using semiconductor quantum dots to fill this need has been provided by experimental observations of radiation hardness in $In_xGa_{1-x}As/GaAs$ quantum dots.

For the experiments, specimens containing $In_xGa_{1-x}As/GaAs$ quantum dots [lenslike islands (≈5 nm thick and ≈25 nm in diameter) of $In_xGa_{1-x}As$ surrounded by GaAs] were fabricated by metal-organic chemical vapor deposition of $In_{0.6}Ga_{0.4}As$ and GaAs on GaAs substrates. For comparison, specimens containing quantum wells (as distinguished from quantum dots) were also fabricated by stopping the growth of $In_{0.6}Ga_{0.4}As$ before the onset of the Stranski-Krastanow transformation [in which quantum dots form spontaneously in a second semiconductor (in

this case, $In_{0.6}Ga_{0.4}As$) deposited on a lattice-mismatched first semiconductor (in this case, GaAs) once the second semiconductor reaches a critical thickness, which is typically a few molecular layers].

In the experiments, the specimens were irradiated with protons at a kinetic energy of 1.5 MeV from a Van de Graaff generator. Next, the light-emitting properties of specimens that had been exposed to a range of proton doses were evaluated in terms of photoluminescence emitted by the specimens at various temperatures. The photoluminescence was excited by light at a wavelength of 514 nm from an argon-ion laser and measured by use of a cooled germanium detector and a lock-in detection technique.



Quantum Dots Retained a Greater Proportion of their original photoluminescence than did quantum wells exposed to the same fluence of 1.5-MeV protons.

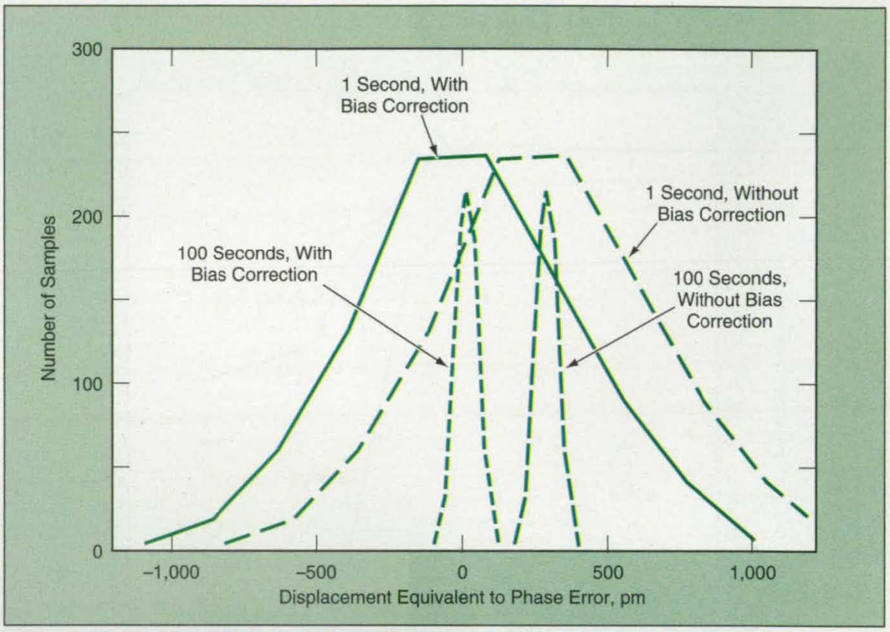
The figure shows the measured integrated normalized photoluminescence intensities from the quantum wells and quantum dots as functions of the proton dose, the normalization being with respect to the zero-dose values. These plots suggest that quantum dots can tolerate about 50 to 100 times as much radiation as quantum wells can. The increase in radiation hardness of quantum dots over quantum wells is all the more significant in that quantum-well optoelectronic devices (e.g., light-emitting diodes) based on quantum wells have already been demonstrated to be an order of magnitude more radiation-hard than are the corresponding conventional optoelectronic devices (e.g., light-emitting diodes based on p/n junctions).

This work was done by Rosa Leon of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Electronic Components and Systems category.*
NPO-21009

Estimating White-Light-Interferometer Phases in Dim Light

Errors in phase measurements are reduced by use of optimal nonlinear least-squares techniques.

NASA's Jet Propulsion Laboratory, Pasadena, California



Histograms Were Generated In Monte Carlo Simulations of the error in phase estimates of an interferometer operating at a wavelength of 725 nm with a total actuator stroke of 900 nm. The estimates were made by use of (a) a prior non-bias correcting algorithm and (b) a bias correcting algorithm of the present method for integration times of 1 and 100 s. The simulations were repeated 1,000 times to obtain the histograms.

A method has been developed to increase the accuracy of estimates of phase differences attributable to the optical-path-length difference between the arms of a long-baseline, white-light interferometer. The method is intended for use in the Space Interferometer Mission (SIM), in which there are requirements to (1) keep the phase error averaged over a 30-second integration time low enough to correspond to a path-length error ≤30 pm and (2) estimate phase differences at a rate of 1 kHz for use in feedback control of the optical-path-length difference of the arms of the interferometer, even when the light is from a distant star or other source that is so dim that the amount of light received from the source amounts to as few as 240 photons per millisecond. The algorithms were developed for monochromatic light, since the combined light is sent through a prism so that light impinging on a single pixel of the detector is nearly monochromatic. Techniques are then used to combine several different monochromatic results into a single, more accurate phase estimate.

The method is also applicable to ground-based interferometers that are required to operate at low light levels. Most prior phase-estimation algorithms for optical interferometers would exhibit significant biases at the low light levels and short integration times like those required for the SIM. These biases are attributable to shot noise and readout noise of the detector. The noise propagation properties of the algorithms themselves are also of concern. Feedback control actuations and vibrations of the interferometer structures and the consequent changes of optical path lengths during sampling and computation periods also contribute to errors.

The present method involves the use of techniques and algorithms that reduce the error from all of these sources. In this technique, covariances of error sources are taken into account in estimating the desired phase differences by use of optimal nonlinear least-squares techniques. In addition to highly accurate estimates of the average phase difference for relatively long integration periods (e.g., 30 seconds), the method provides estimates of the phase at sub-sampling steps (e.g., 1 millisecond) for feedback control. A

Kalman smoothing filter is used to reduce the error associated with temporal variations of phases. The advantage of this method over prior methods is that the phase is estimated more accurately (see figure). The disadvantage is that in comparison with prior methods, this method entails more computation.

This work was done by Scott Basinger and Mark Milman of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Physical Sciences category.*

This software is available for commercial licensing. Please contact Don Hart of the California Institute of Technology at (818) 393-3425. Refer to NPO-30337.

System Would Detect Aircraft to Turn Off Upward-Aimed Laser

This system could turn off the laser with a safety time margin of 0.4 second.

NASA's Jet Propulsion Laboratory, Pasadena, California

An electronic system based on long-wavelength infrared (LWIR) sensors is being developed to detect aircraft flying near an upward-aimed, high-power laser beam. In the intended application, the system would alert a human laser operator and/or generate a signal to turn off the laser whenever an aircraft came within a specified exclusion zone — an approximately conical zone, surrounding the laser beam, from which the aircraft must be excluded to protect the human occupants of the aircraft against the laser beam. There could be a potential market for systems like this one in the laser-light-show, free-space laser communication, and lidar industries.

The use of LWIR (in contradistinction to shorter wavelengths) makes it possible to detect the blackbody emission from the skin of an aircraft; it is not necessary to rely on emission from hot engine parts. The system includes two LWIR cameras: a wide-field camera of 18-mm focal length and a narrow-field camera of 75-mm focal length. Both cameras have focal-length/aperture-diameter ratios ("f numbers") of about 1.

The performance of the system was analyzed in tests on observation of several airplanes ranging from a single-engine propeller to full-size commercial multiengine jet transport. In all cases, the system was found capable of detecting and providing alerts for airplanes flying at altitudes between 500 and 11,000 ft (approximately between 0.2 and 3.4 km). In each case, the system provided an alert at least 0.5 second before the aircraft intercepted the laser beam. Inasmuch as the time to close the laser shutter was 0.1 second, the system thus provided a margin of 0.4 second.

This work was done by Keith Wilson, Vachik Garkanian, and Tom Roberts of Caltech and Brian Smithgall of Image Labs International for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Electronic Components and Systems category.* *NPO-30521*

All-Reflective Computed-Tomography Imaging Spectrometers

These instruments could form multispectral images of transient scenes from ultraviolet through infrared.

NASA's Jet Propulsion Laboratory, Pasadena, California

Computed-tomography imaging spectrometers (CTISs) that contain only reflective optics (instead of at least some refractive optics) have been proposed. As is the case for other types of optical instruments, the change to all-reflective designs for CTISs would eliminate the chromatic aberration exhibited by refractive optics and would relieve designers of the task of finding optical materials with adequate transmissivity over wavelength ranges of in-

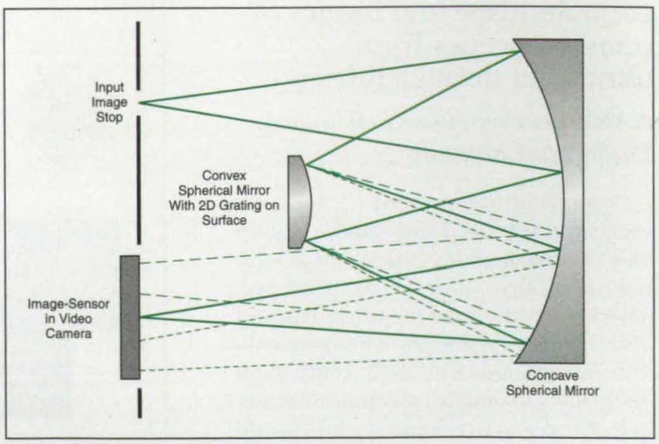
terest. As a result, it would be easier to scale CTIS designs to different wavelength ranges from ultraviolet through long-wavelength infrared.

The CTIS concept and transmissive implementation were described previously in "Improvements in Computed-Tomography Imaging Spectrometry" (NPO-20561) *NASA Tech Briefs*, Vol. 24, No. 12 (December 2000), page 38. To recapitulate: A CTIS offers capabilities for imaging a scene with spatial, spectral, and temporal resolution. In the case of a CTIS that contains refractive optics, the spectral disperser is a two-dimensional diffraction grating made of a transparent material and positioned between two relay lenses in a video imaging system. In the absence of the grating, the system would produce ordinary images of the scene in its field of view. In the presence of the grating, the image on the focal plane contains both spectral and spatial information because the multiple diffraction orders of the grating give rise to multiple, spectrally dispersed images of the scene. By use of algorithms adapted from computed tomography, the image on the focal plane can be processed into an "image cube" — a three-dimensional collection of data on the image intensity as a function of the two spatial dimensions (x and y) in the scene and of wavelength (λ). Thus, both spectrally and spatially resolved information on the scene at a given instant of time can be obtained, without scanning, from a single video snapshot.

The figure shows the basic optical layout of one of many possible all-reflective CTIS designs. This design features the Offner configuration, which provides for relay of images by two concentric spherical mirrors. Traditional slit-type imaging spectrometers (not CTISs) in the Offner configuration have become popular in the past several years because they can be very compact and exhibit excellent imaging. In order to implement a CTIS in this Offner configuration, it will be necessary to fabricate the two-dimensional diffraction grating on the convex mirror surface. Heretofore, this would have been a formidable or even an impossible task; however, it is now feasible, thanks to recent advances in analog-relief electron-beam lithography on curved surfaces.

This work was done by Daniel Wilson, Paul D. Maker, Richard Muller, and Pantazis Mouroulis of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Physical Sciences category.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Management Office–JPL; (818) 354-7770. Refer to NPO-20836.



This **Optical Layout of a CTIS** in the Offner configuration is part of a preliminary design for operation in the wavelength range of 6 to 10 µm. Calculations show that the performance of this CTIS would be close to diffraction-limited.

Optical-Based Method for Characterizing Protein Crystals

Sizes and crystalline structures can be monitored in real time.

Marshall Space Flight Center, Alabama

A method of characterization of growing of protein crystals involves the utilization of an optical imaging technique known as spatial phase imaging. The methods used heretofore have been, variously, invasive (e.g., adding a dye that is absorbed by the protein of interest), destructive (e.g., crushing protein/salt-crystal mixtures and observing differences between the crushing of salt and protein), or time-consuming (x-ray crystallography). In contrast, the present method is noninvasive, nondestructive, and rapid.

Spatial phase imaging involves the use of proprietary filters. In the present method, one uses a single camera to acquire a series of spatial phase images of a specimen [which could include one or more protein crystal(s) mixed with one or more salt crystal(s)]. One then digitally processes the image data by use of algorithms that extract information on the three-dimensional properties of the protein crystal of interest, including its volume and some aspects of its crystalline structure. This information can be processed further to extract information about the symmetry of the crystal and to detect flaws.

It is possible, in the processing of the image data, to discriminate against salt crystals or remove images of them from the scene, leaving only the protein-crystal images for analysis. To take advantage of this capability, one uses a different set of spatial phase components in algorithms developed specially for this purpose.

This method is not expected to eliminate the need for x-ray crystallography at the later stages of research on a given protein. However, as a means of identification and preliminary analysis of protein crystals, it could eliminate or greatly reduce the need for x-ray crystallography as a screening technique in the early stages. In addition to being noninvasive and nondestructive, the present method yields results so rapidly that it is suitable for real-time monitoring and, hence, for providing feedback for process control. Hence, this method is expected to accelerate the search for conditions to optimize the growth of proteins and to be a means of automation of the growth of high-quality protein crystals.

This work was done by Blair A. Barbour and Stephen Benson of Photon-X, Inc., for **Marshall Space Flight Center.** *For further information, contact the company at (256) 740-3416.*
MFS-31716

Rugged Laser-Diode Oxygen Sensor

John F. Kennedy Space Center, Florida

A rugged laser-diode oxygen sensor is being developed for detecting leaks of oxygen from diverse systems, including rocket engines, cryogenic systems, and medical equipment. The sensor is required to have a range of 250 to 250,000 parts per million, to be accurate within 5 percent, to be capable of operating at any temperature between –224 °F (–142 °C) to +175 °F (79 °C), and to have a response time ≤10 seconds. Rugged, low-temperature-capable laser-diode sensors were known previously, but were not sensitive enough. A prototype of the developmental sensor with the measurement range indicated above, having noise less than 5 percent of reading, and response time of 1 second has been demonstrated. The required sensitivity was achieved in the prototype by use of a Herriot cell (a multipass absorption cell) of 20 passes that had a 3-m absorption path length. A conceptual design for an instrument suitable for a rocket-launch site calls for a 4.6-m-path-length Herriot cell, overall package dimensions of 7 by 3 by 12 in. (about 17.8 by 7.6 by 30.5 cm), and a weight <10 lb (mass <4.5 kg).

This work was done by Bruce W. McCaul of Oxigraf, Inc., for **Kennedy Space Center.**

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

Bruce W. McCaul, President
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Refer to KSC-12086, volume and number of this NASA Tech Briefs *issue, and the page number.*

Technologies of the Month

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Processor Design for Simplified Component Replacement

AGFA

A machine or processor is usually built of components that carry out tasks in a programmed sequence, as directed by a central processing unit (CPU). Typically the components are connected via an interface board to the CPU. When a component needs to be replaced with a component of a different type the CPU must be reprogrammed. When components are used in different systems and locations, reprogramming and testing the new combinations can become an immense task.

Alternatively, this processor or system architecture stores information on the characteristics and controlling functions of components locally with each component. This local information can be removed and replaced by a service engineer while changing a component. Storage of information concerning the function of the machine remains in the CPU.

The CPU communicates with the components through a controlled area network, either by sending tagged messages to the smart nodes of the components, which pick up the message and convert it to physical actions, or by interrogation of the components by the CPU, which extracts the component information and sends physical data messages. In any case, separate wiring of each component to the CPU is avoided.

This design is used for controlling and remote monitoring and servicing of a lithographic printing plate processor (shown), but can be applied to a wide range of devices.

Get the complete report on this technology at:
www.nasatech.com/techsearch/tow/processor.html
Email: nasatech@yet2.com
Phone: 617-557-3837

Product Guide: HeNe Lasers

Wavelength (nm)	Output Power (mW)	Beam Diameter (mm)	Beam Divergence (mrad)	Polarization	Safety Classification (CDRH)	Features	Company	Model
543	0.50	0.85	1.00	500:1	IIIa	Cylindrical	LASOS	LGK-7786 P50
543	1.00, 1.50	0.88	0.85	Random	IIIa	Cylindrical	LASOS	LGK-7785-100, -150
543	2.00, 2.50	0.88	0.85	Random	IIIa	Cylindrical	LASOS	LGK-7785-200, -250
543.5	0.10	0.88	2.35	Random	II	Rectangular	Melles Griot	05 SGR 810
543.5	0.20	0.63	1.26	Random	II	Cylindrical	Melles Griot	25 LGR 025
543.5	0.30	0.66	1.03	Random	IIIa	Cylindrical	Coherent	31-2264
543.5	0.30	0.77	0.90	Linear	IIIa	Cylindrical	Melles Griot	25 LGP 151
543.5	0.30	0.79	0.88	>500:1	IIIa	Cylindrical	Coherent	31-2280
543.5	0.30	0.79	0.89	Linear	IIIa	Cylindrical	Melles Griot	25 LGP 173
543.5	0.50	0.80	1.01	Random	IIIa	Cylindrical	Melles Griot	25 LGR 151
543.5	0.80	0.79	0.88	Random	IIIb	Cylindrical	Melles Griot	25 LGR 173
543.5	1.00	0.86	0.81	>500:1	IIIa	Cylindrical	Coherent	31-2298
543.5	1.00	0.88	0.81	Linear	IIIa	Cylindrical	Melles Griot	25 LGP 193
543.5	1.50	0.86	0.81	Random	IIIa	Cylindrical	Melles Griot	25 LGR 193
543.5	2.00	0.86	0.81	Random	IIIa	Cylindrical	Melles Griot	25 LGR 393
543.5	2.00	0.88	0.99	Random	IIIa	Cylindrical	Coherent	31-2772
594.1	0.35	0.63	1.26	Random	Not certified	Cylindrical	Melles Griot	25 LYR 025
594.1	0.75	0.80	1.01	Random	IIIa	Cylindrical	Melles Griot	25 LYR 151
594.1	0.10	0.88	2.35	Random	II	Rectangular	Melles Griot	05 SYR 810
594.1	1.00	0.75	0.92	Linear	IIIa	Cylindrical	Melles Griot	25 LYP 173
594.1	2.00	0.75	0.92	Random	IIIa	Cylindrical	Coherent	31-2230
594.1	2.00	0.75	0.92	Random	IIIa	Cylindrical	Melles Griot	25 LYR 173
611.9	0.50	0.47	1.70	Random	II	Rectangular	Melles Griot	05 SOR 810
611.9	2.00	0.75	1.05	Random	IIIb	Cylindrical	Melles Griot	25 LOR 151
612	2.00	0.80	1.01	Random	IIIa	Cylindrical	Coherent	31-2207
632.8	0.50	0.46	1.77	Random, Linear (LHP)	II	Cylindrical	Melles Griot	25 LHR 213, 25 LHP 213
632.8	2.50	0.52	1.53	Random, Linear (LHP)	IIIa	Cylindrical	Melles Griot	25 LHR 691, 25 LHP 691
632.8	0.50	0.48	1.70	5000:1	II	Stabilized	Melles Griot	05 STP 909
632.8	0.50	0.48	1.70	Unpolarized	II	Rectangular	Thermo Oriel	79251, 79253
632.8	0.50	0.48	1.70	500:1	II	Rectangular	Thermo Oriel	79255, 79257
632.8	0.50	0.34	2.40	Random	IIIa	Cylindrical	LASOS	LGR-7656
632.8	0.50	0.47	1.70	Random	II	Cylindrical	Melles Griot	05 LLR 811
632.8	0.50	0.47, 0.45 (SRP)	1.70, 1.80 (SRP)	Random, Linear (SRP)	II	Rectangular	Melles Griot	05 SRR 810, 05 SRP 810
632.8	0.50	0.49	1.75	200:1	IIIa	Cylindrical	LASOS	LGR-7650, LGK-7650
632.8	0.60	0.49	2.00, 1.70 (LGK)	Random	IIIa	Cylindrical	LASOS	LGR 7655, LGK-7655
632.8	0.75, 1.00	0.52	0.13	100:1	II	Cylindrical	LASOS	LGK-7657
632.8	0.80	0.46	1.77	>500:1	IIIa	Cylindrical	Coherent	31-2009
632.8	0.80	0.46	1.77	Random	IIIa	Cylindrical	Coherent	31-2017
632.8	0.80	0.47, 0.45 (SRP)	1.70, 1.80 (SRP)	Random, Linear (SRP)	IIIa	Rectangular	Melles Griot	05 SRR 812, 05 SRP 812
632.8	1.00	0.59	1.35	Random, Linear (LHP)	IIIa	Cylindrical	Melles Griot	25 LHR 111, 25 LHP 111
632.8	1.00	0.48	1.70	Unpolarized	IIIa	Rectangular	Thermo Oriel	79241, 79243
632.8	1.00	0.48	1.70	500:1	IIIa	Rectangular	Thermo Oriel	79245, 79247
632.8	1.00	0.54	1.50	5000:1	IIIa	Stabilized	Melles Griot	05 STP 911
632.8	1.00	0.50	1.60	1000:1	IIIa	Stabilized	Melles Griot	05 STP 901, 903, & 905
632.8	1.00	0.50	1.80	Linear	IIIa (OEM only)	Stabilized	Spectra-Physics	117A
632.8	10.00	0.65	1.24	Random, Linear (LHP)	IIIb	Cylindrical	Melles Griot	25 LHR 991, 25 LHP 991

Wavelength (nm)	Output Power (mW)	Beam Diameter (mm)	Beam Divergence (mrad)	Polarization	Safety Classification (CDRH)	Features	Company	Model
632.8	10.00	0.65	1.24	>500:1	IIIb	Cylindrical	Coherent	31-2082
632.8	10.00	0.65	1.24	Random	IIIb	Cylindrical	Coherent	31-2090
632.8	10.00	0.70	1.40	Random	IIIb	Cylindrical	LASOS	LGK-7653-8
632.8	15.00	1.00	1.00	Random, 500:1 (P)	IIIb	Cylindrical	LASOS	LGK-7665, LGK-7665P
632.8	17.00	0.96	0.84	Random, Linear (LHP)	IIIb	Cylindrical	Melles Griot	25 LHR 925, 25 LHP 925
632.8	17.00	0.95	0.84	>500:1	IIIb	Cylindrical	Coherent	31-2108
632.8	17.00	0.95	0.84	Random	IIIb	Cylindrical	Coherent	31-2196
632.8	18.00	1.00	1.00	Random, 500:1 (P18)	IIIb	Cylindrical	LASOS	LGK-7665-18, P18
632.8	2.00	0.59	1.35	Random, Linear (LHP)	IIIa	Cylindrical	Melles Griot	25 LHR 121, 25 LHP 121
632.8	2.00	0.76	1.06	Random, Linear (LHP)	IIIa	Cylindrical	Melles Griot	25 LHR 073, 25 LHP 073
632.8	2.00	0.75	1.20	Random	IIIa	Cylindrical	LASOS	LGK-7672
632.8	2.00	0.79	1.00	>500:1	IIIa	Cylindrical	Coherent	31-2025
632.8	2.00	0.79	1.00	Random	IIIa	Cylindrical	Coherent	31-2033
632.8	2.00	0.75	1.20	Random	IIIa	Cylindrical	LASOS	LGR 7621 S
632.8	2.00	0.75	1.20	500:1	IIIa	Cylindrical	LASOS	LGR-7634, LGK-7634
632.8	20.00	1.00	1.00	Random	IIIb	Cylindrical	LASOS	LGK-7665-20
632.8	25.00	1.24	0.68	Linear	IIIb	Rectangular	Melles Griot	25 LHP 828
632.8	25.00	1.25	0.80	1000:1	IIIb	Cylindrical	LASOS	LGK-7626
632.8	25.00	1.25	0.66	Horizontally, Vertically (V)	IIIb	Rectangular	Spectra-Physics	127-25, 127-25V
632.8	25.00, 35.00	1.25	0.66	Horizontally	IIIb (OEM only)	Cylindrical	Spectra-Physics	107B
632.8	28.00	1.25	0.80	1000:1	IIIb	Cylindrical	LASOS	LGK-7676
632.8	35.00	1.24	0.68	Linear	IIIb	Rectangular	Melles Griot	25 LHP 928
632.8	35.00	1.25	0.66	>500:1	IIIb	Cylindrical	Coherent	31-2140
632.8	35.00	1.25	0.66	Horizontally, Vertically (V)	IIIb	Rectangular	Spectra-Physics	127-35, 127-35V
632.8	4.00	0.80	1.00	>500:1	IIIb	Cylindrical	Coherent	31-2041
632.8	4.00	0.80	1.00	Random	IIIb	Cylindrical	Coherent	31-2058
632.8	5.00	0.80	1.00	Random, Linear (LHP)	IIIb	Cylindrical	Melles Griot	25 LHR 151, 25 LHP 151
632.8	5.00	0.80	1.10	Random	IIIb	Cylindrical	LASOS	LGR 7627, LGK-7627
632.8	5.00	0.80	1.10	500:1	IIIb	Cylindrical	LASOS	LGR-7628, LGK-7628
632.8	7.00	1.02	0.79	Random, Linear (LHP)	IIIb	Cylindrical	Melles Griot	25 LHR 171, 25 LHP 171
632.8	7.00	1.02	0.79	>500:1	IIIb	Cylindrical	Coherent	31-2066
632.8	7.00	1.02	0.79	Random	IIIb	Cylindrical	Coherent	31-2074
633	0.50	0.57	1.41	Random	II	Cylindrical	Newport	R-31003, R-31008
633	>1.50	0.60	1.60	Linear	IIIa	Stabilized	Newport	117A
633	2.00	0.83	0.84	Random	IIIa	Cylindrical	Newport	R-30972
633	5.00	0.80	1.01	Random, 500:1 (-991)	IIIb	Cylindrical	Newport	R-30990, R-30991
633	12.00	0.88	0.92	Random, 500:1 (-993)	IIIb	Cylindrical	Newport	R-30992, R-30993
633	17.00	0.98	0.82	500:1	IIIb	Cylindrical	Newport	R-30995

Refer to manufacturer Web sites for additional products and complete ordering information.

Company	URL
Coherent Inc.	www.coherentinc.com
LASOS Lasertechnik GmbH	www.lasos.com
Melles Griot	www.mellesgriot.com
Newport	www.newport.com
Spectra-Physics	www.splasers.com
Thermo Oriel	www.thermo.com

New Products

Product of the Month

Hand-Held IR Camera

The ThermaCAM® E2 IR camera from FLIR Systems (N. Billerica, MA) is a compact, lightweight thermal analysis camera that finds and documents faults in electronic components, assemblies, and mechanical systems before they result in costly design flaws or warranty returns. All E-series cameras include a maintenance-free, uncooled microbolometer IR detector that produces highly sensitive thermal images, which can be viewed on the camera's integral high-intensity 2.5" color LCD. Engineers can highlight and analyze problems, store images, and share results with colleagues in the field, lab, or on the factory floor. TV rate (60Hz) imaging lets users quickly scan moving targets and record subtle temperature changes in real-time.

For Free Info visit www.nasatech.com/flir

High-Precision Vertical Lift Stage

Aerotech's (Pittsburgh, PA) patented ANT-4V High-Precision Vertical Lift Stage, for vertical alignment of high-precision components, features high speed (50 mm/second), high resolution (2 nm), and high accuracy (200 nm) in one compact package. Its non-contact direct drive employs high-accuracy direct position feedback. All the critical elements of the ANT-4V were selected to operate in a 24/7 environment and, unlike screw- or piezo-based vertical stages, the ANT-4V requires no maintenance.

For Free Info visit www.nasatech.com/aerotech

Position Sensors

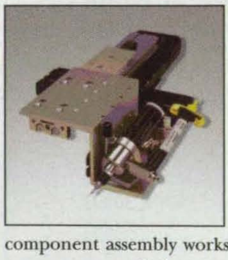
The 75S2DC series of DC-operated industrial LVDT position sensors from Sentech (North Hills, PA) are designed for use in factory automation and industrial process applications. The units offer linear measurement ranges from 0 to 0.100" (0 to 2.54mm) and 0 to 20" (0 to 508mm) with a total of 7 intermediate ranges. The 75S2DC operates from +24 V DC, provides low noise, and +1 to +10V DC output for full displacement. The also units have stainless steel outer housings and epoxy sealing.

For Free Info visit www.nasatech.com/sentech

Hybridized Photodetectors

Advanced Photonix's (Camarillo, CA) new line of hybridized photodetectors consist of a PIN photodiode and transimpedance amplifier integrated within a hermetically sealed TO-5 package. An external feedback resistor and capacitor allow the transimpedance gain and bandwidth to be set by the user. This provides a simple means of matching detector gain to the incident light level, even if it has not been determined in advance. Standard detector active areas are 5.1 mm² and 100mm², but different detector sizes and amplifier characteristics can be produced upon request.

For Free Info visit www.nasatech.com/advanced



Automatic Adhesive Dispensing & Curing

ProBond, a new bonding option for EXFO Electro-Optical Engineering's (Quebec City, Canada) ProAlign 5000 component assembly workstation, automatically dispenses a controlled amount of adhesive, and then cures it with light. The new option increases repeatability, which shortens the R&D phase, increases yield and throughput, and provides for higher quality and performance of advanced optical components including planar lightwave circuits (PLCs), switches and transceivers.

For Free Info visit www.nasatech.com/exfo

High Power Laser Diode

Photonic Products (Bishops Stortford, UK) introduces the HL6512MG, Hitachi's high output, red laser diode, with a rated optical output power of 50W CW (70mW pulsed) at 658nm. The AlGaInP laser diode has a multi-quantum well (MQW) structure and a hermetically sealed, small (5.6mm) package. The small variation of beam divergence to optical output power makes it possible to suppress the variation of spot size between the higher and lower output powers, making it suitable as a light source for large capacity re-writable optical disc memories.

For Free Info visit www.nasatech.com/photonicproducts

Optical Grade Plastic

Gigahertz-Optik's (Newburyport, MA) Optically Diffuse Material (OP.DI. MA.) is a low-cost, durable, and cleanable white optical grade plastic useful for lighting design, laser, and reflection/transmission applications. White reflectance standards, laser cavities, and integrating sphere coatings are typical. Features include diffuse reflectance of >98 % from 400-1600 nm and >95% from 250-2000 nm, uniform reflectance across a wide spectral range, and high temperature operation up to 200°C (300°C short exposures), long term UV stability, and high maximum permissible radiation flux densities.

For Free Info visit www.nasatech.com/gigahertz

High-Power Vision System

PPT Vision's (Eden Prairie, MN) IMPACT™ high-speed machine vision "micro-system" is priced competitively with vision sensors. The system's power comes from a dedicated 600Mhz high-speed, processor and sub-pixel software algorithms for a broad range of inspection tasks including Pattern Find, Blob, and Edge Find. IMPACT can achieve 60 full-frames per second image capture rate, and even greater speeds when using the built-in support for partial scanning. Operator interfaces can be generated quickly by using the new point-and-click GUI software.

For Free Info visit www.nasatech.com/pptvision

Compact Fiber Optic Illuminators

MH21 fiberoptic illuminators from Conquest Global (Arcadia, CA) are designed to facilitate integration into a variety of vision systems. These light sources produce little heat radiation, measure 4.5" x 3.2" x 2.3", weigh less 1 lb., and feature very quiet operation. The MH21 family consists of four models: an electronic on/off shutter, a mechanically adjustable shutter, without a shutter, or with a combination of electronic and mechanical shutters. All models are available as completely housed units or as light engines.

For Free Info visit www.nasatech.com/conquest

Sampling Modules

The Tektronix (Beaverton, OR) 80C10 optical and 80E06 electrical sampling modules for the CSA8000B Communications Signal Analyzer are the latest in a series of optical test products designed to speed development of emerging 40 Gb/s components and network elements. The 80C10 Optical Sampling Module (shown) makes effective production testing of OC-768/STM-256 elements possible. The 80E06 Electrical Sampling Module, with 70+ GHz electrical bandwidth, enables manufacturers to more accurately characterize high-speed 40 Gb/s components.

For Free Info visit www.nasatech.com/tektronix1102

Thin-Film Metrology Tool

The FilmTek™ 2000M-DUV from Scientific Computing International (Carlsbad, CA) is a new instrument for R&D and volume production of 90-nm semiconductor devices. The instrument provides complete characterization of films used in semiconductor fabrication including inorganic and polymer-based low-K (solid or porous), high-K, amorphous, Silicon On Insulator (SOI) structures, and silicon-germanium films. It measures thickness and optical film properties simultaneously and offers a measurement spot size as small as 5-μm diameter.

For Free Info visit www.nasatech.com/sci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Software for an Autonomous Constellation of Satellites

The Autonomous Sciencecraft Constellation (ASC) software has been developed for Techsat-21 — a group of small satellites, to be launched by the Air Force Research Laboratory in 2004, intended to demonstrate the feasibility of groups of satellites cooperating in the performance of tasks. The task in this initial application will be scientific radar observations of the Earth, using the satellites flying in precise formation to synthesize a wide-aperture antenna. The ASC software will enable Techsat-21 to function with a high degree of autonomy, thereby reducing the utilization of limited communication bandwidth and reducing the need for labor-intensive sequencing of commands and analysis of scientific data on the ground. The software will provide onboard scientific analysis of image data, replanning, robust execution of plans, model-based estimation and control, and formation-flying control to increase science return through a combination of intelligent selection of downlinks and autonomous retargeting on the basis of "interesting" features in the scientific data.

This program was written by Robert Sherwood, Russell Knight, Gregg Rabideau, Steve Chien, Daniel Tran, Barbara Engelhardt, Rebecca Castaño, Timothy Stough, Michael Burl, and Ashley Davies of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Software category.*

This software is available for commercial licensing. Please contact Don Hart of the California Institute of Technology at (818) 393-3425. Refer to NPO-30355.

Training by Use of Games Played via the Internet

A software system that resides on a server delivers training via the Internet to users of client computers. Administrators can also interact with the system via client computers. The training lessons are in the form of trivia games, which are implemented by a game-engine software subsystem that is independent of game content. The system software incorporates two commercially available web-development programs: Macromedia Flash and Macromedia ColdFusion. The game engine is constructed in Macromedia Flash, which is fast becoming the Web standard for interactivity. Game content and student information are stored in a database. An application program written in ColdFusion Markup Language (CFML) causes the uploading of content and student information to the database when game play is completed. Another program written in CFML enables an administrator to edit game content, review and edit student information, and view game statistics via Web-browser software. To change a game, an administrator simply fills out one or more Web-based form(s). The software in the student's computer must include a Web-browser program with the Flash player plug-in program.

This program was written by David A. Penca and Angela Smibert of Dynacs, Inc., and Edward Farrar of Netlander for **Kennedy Space Center**. *For further information, please contact:*

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Refer to KSC-12239

Software for Designing Thermal Protection for Spacecraft

Traj and Traj.CGI are computer programs for designing thermal-protection systems (TPSs) for spacecraft that must survive re-entry into planetary atmospheres. Together with a separately developed program denoted FIAT, Traj and Traj.CGI are integral parts of NASA's Entry Vehicle Integrated Design System. Traj simulates trajectories for a wide variety of spacecraft by use of a three-degree-of-freedom trajectory model coupled with a set of approximate functions for calculating heating effects caused by hypersonic passage through an atmosphere. Included within Traj are equilibrium thermodynamics tables, atmospheric tables for various planets, gravitational data, and aerodynamic data for a large set of spacecraft. Traj.CGI is a common-gateway-interface code that enables users to gain access to Traj simultaneously through readily available Internet browser software, using dynamically generated Hypertext Markup Language (HTML) pages. Traj.CGI passes data generated by Traj to plotting software packages for immediate browser display or to postprocessing software (e.g., FIAT, which is used to size components of TPSs).

These programs were written by Gary Allen, Mark Loomis, David Olynick, Paul Wercinski, Peter Gage, Ethiraj Venkatapathy, and Michael Wright of **Ames Research Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Software category.*
ARC-14377

Software for Validating Planetary Data Volumes

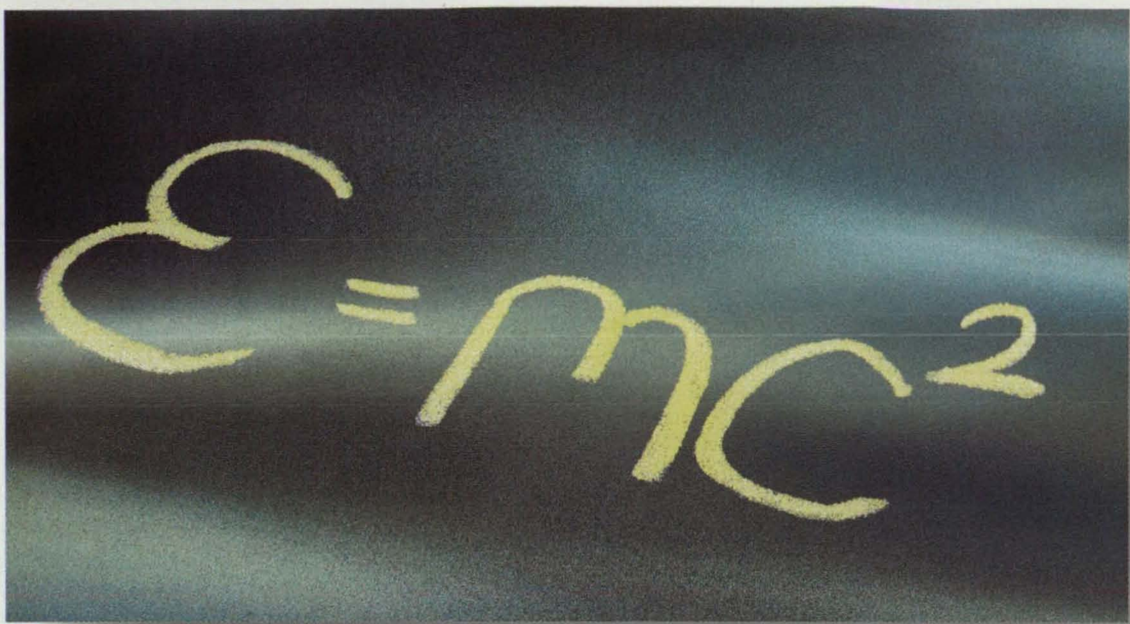
The PDS Validation Toolkit is an integrated set of scripts and computer programs for determining whether data recorded on compact disk (CD) or digital video disk (DVD) conform to the standards of the Planetary Data System (PDS). The software provides both command-line and graphical user interfaces, through which the user can direct the software to analyze the data, metadata, and volume structure of a given volume and determine adherence to the PDS validation standards. After analyzing the volume, this software generates a report that describes all the errors (deviations from the PDS standards) in the volume.

This program was written by Joel Wilf of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Software category.*

This software is available for commercial licensing. Please contact Don Hart of the California Institute of Technology at (818) 393-3425. Refer to NPO-30364.

Java Version of Embedded Web Software Server

Tempest is a computer program that functions as a HyperText Transfer Protocol (HTTP) server for embedded systems. Tempest enables remote command and control of embedded systems. Tempest accepts HTTP requests from standard Web-browser programs running on remote client computers and returns HyperText Markup Language (HTML) files to the browsers. Tempest is capable of serving up


$E=mc^2$

a variety of Web-based data files and application programs, including HTML files; Java applets; Common Object Request Broker Architecture (CORBA) client programs; Virtual Reality Modeling Language (VRML) files; static and dynamic video images in Joint Photographic Experts Group (JPEG), Graphic Image File (GIF), Moving Pictures Experts Group (MPEG), and Audio/Video Interleave (AVI) formats and in other common formats; audio files; and files in other formats specified by the Tempest user. Features, options, and capabilities of Tempest include encrypted identification and password challenges to remote clients, separate configuration files, exception handling, optional logging of client Internet Protocol (IP) access, optional debugging, optional connection of persistent clients, and optional assignment of listening ports. The present version of Tempest, written in the Java programming language, is designed to run on any operating system for which there exists a Java virtual machine.

This program was written by David W. York, Joseph G. Ponyik, Lisa M. Lambert, and Maria Babula of **Glenn Research Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Software category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-17294.

Image Display Component of JADE

A Java bean that offers high performance display of images has been developed as a component of the Java Advanced Display Environment (JADE) computer program. This component works asynchronously, loading and/or computing image tiles as needed in background threads. In so doing, it enables a main graphical-user-interface (GUI) thread to remain responsive even while loading huge images: scrolling and other actions can occur while images are being read in and/or computed. This component performs well even when loading images larger than 2 gigabytes. Display of such large images would not be practical without background processing of tiles. Scrolling is fast, regardless of image size, because the GUI is not hung while waiting for tiles to be loaded. This component is written using Java Advanced Imaging (JAI) 1.1. It is neutral with respect to image file format, so it can display almost any Java image, and it is platform-independent because it is pure Java. It also supports overlay of user-supplied graphics on images — a capability that can be used for such purposes as annotation of images, generating tie-point plots, and painting of complex or dynamic cursor shapes.

This program was written by Robert Deen of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Software category.*

This software is available for commercial licensing. Please contact Don Hart of the California Institute of Technology at (818) 393-3425. Refer to NPO-30471.

Software for Analyzing Scientific Data Aboard a Spacecraft

A computer program designed for execution aboard an exploratory spacecraft analyzes scientific data (especially image data) in order to (1) enable the reservation of limited communication resources for transmission of data likely to be of significant scientific value and (2) enable automated, rapid response to take advantage of fleeting, unanticipated opportunities for important scientific observations. The program can also be executed on Earth to analyze data acquired in prior spacecraft missions. At its present state of development, the program implements change-detection and discovery algorithms that recognize scientifically interesting features in images of terrain of remote planets, moons, asteroids, and the like. These algorithms utilize examples of previously identified targets to generate efficient mathematical models for identifying new targets of the same type across a continuous range of scales. In tests thus far, the program recognized 80 percent of craters, with a false-alarm rate of 12 percent, in Lunar images larger than four pixels acquired by the Clementine spacecraft. The program has also been shown to be capable of discovering volcanoes on Venus, sand dunes on Mars, and ice geysers (cryovolcanoes) on Neptune's moon Triton.

This program was written by Ashley Davies, Eric Mjolsness, Joseph Roden, Michael Burl, Rebecca Castano, Robert Sherwood, Steve Chien, and Timothy Stough of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Software category.*

This software is available for commercial licensing. Please contact Don Hart of the California Institute of Technology at (818) 393-3425. Refer to NPO-30442.

Variable Submillimeter-Wave Delay Line for Cryogenic Use

Stiffness, size, vacuum adhesion, range, and number of parts were considered in designing this device.

NASA's Jet Propulsion Laboratory, Pasadena, California

A variable delay line is being developed as part of a far-infrared or submillimeter-wavelength interferometer that would operate in a vacuum in the cryogenic temperature range. No such delay line for spatial interferometry has previously been built for operation under these conditions.

The delay line includes an aluminum carriage supported on four wheels that are constrained, by a set of preloaded steel straps, to move along straight lines. The only friction that occurs in the delay line is rolling friction between different materials; this aspect of the design minimizes the risk of vacuum adhesion between parts made of similar metals. Relative to a competing design based on flex pivots, the roller design of this device affords greater robustness, stiffness, range of motion, and compactness, all with fewer parts.

This work was done by James Moore, Mark Swain, and Peter Lawson of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Mechanics category.*

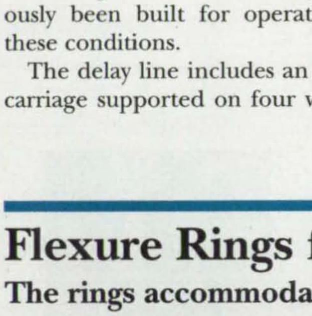
NPO-21167

Flexure Rings for Centering Lenses

The rings accommodate fabrication tolerances and thermal-expansion mismatches.

NASA's Jet Propulsion Laboratory, Pasadena, California

Specially shaped mounting rings keep lenses precisely centered, regardless of temperature, in the lens housings of cameras and other optical systems. These rings feature (1) well-defined contact spots for alignment, plus (2) relieved surfaces that form flexures to accommodate small manufacturing tolerances and differences among the thermal expansions of lenses, lens housings, and the rings themselves. These rings are made by numerically controlled machining of recently developed clean, strong, machinable plastics.



The Elastomeric Ring Holds the Lens with its three inner concave arced stubs and engages the lens housing with its three outer convex arced stubs. Thermal expansion and/or contraction of the lens, the housing, and/or the ring itself are absorbed by flexure of the ring. For greater precision, a ring could be made with six inner and six outer stubs.

The figure illustrates a prototype ring of this type, made from a commercial polyimide. First, the inner and outer cylindrical surfaces were machined to established precise inner and outer diameters. Next, with the ring mounted in a bracing fixture, three flats were machined on the outside and relieved surfaces were cut on the inside. Thus, the three remaining convex arcs on the outer surface of the ring would make contact with the inner surface of the lens housing, the three remaining concave arcs on the inner surface of the ring would make contact with the lens, and the outer flats and the inner relief cuts would provide the required small amount of flexibility to accommodate thermal-expansion mismatches while keeping the lens centered.

This work was done by Virginia G. Ford of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Mechanics category.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Management Office–JPL; (818) 354-7770. Refer to NPO-19518.

Precise Air Bearings Redesigned

A simplified design affords low friction at minimum airflow.

Marshall Space Flight Center, Alabama

Highly precise air bearings for suspending objects over an epoxy flat floor in a laboratory have been developed. These bearings float on airgaps 3 to 5 mil (about 0.08 to 0.13 mm) thick. They are modern versions of precise air bearings, developed during the 1960s, that offer a working coefficient of friction of only 1/16,000. The basic design of these bearings can be scaled easily for different loads and airflows.

When more air bearings were needed in the laboratory, commercial air bearings were evaluated and found not to afford stability of airgaps comparable to that of the 1960s air bearings. The shop in which

the 1960s air bearings were built had been disbanded before 1986 and the original drawings lost. Hence, it was decided to design and build modern versions of the 1960s air bearings.

Each of the 1960s air bearings includes precise brass orifices pressed into recesses on the bottom surface of a bottom section. After insertion of the orifices, the bottom surface was manually lapped to a precise flatness. On top of the bearing, there is a complex conical section with a spherical knob that fits into a socket in the experimental apparatus with which the bearing is to be used. The conical top section is sealed to the bottom section by use of an O ring and rings of many bolts.

The bottom section of a bearing of the present improved type is slowly and precisely machined from a single piece of aluminum. The machining yields the requisite flatness; precise lapping is not needed for flatness, though simple lapping can be performed to remove tooling marks. Spherical relief recesses are machined on both sides of each orifice of an integral annular plenum; this aspect of the design reduces (in comparison with the corresponding aspects of designs of other air bearings) turbulence in the air flowing out of the bearing and facilitates cleaning.

The top section, made from a simple flat plate, includes a simple ball nose recess sealed with grease. The top section is attached to the bottom section by four to eight bolts. The air bearing is attached, by means of a threaded ball bearing, to the apparatus with which it is to be used.

This work was done by Charles T. Cowen of **Marshall Space Flight Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Mechanics category.*
MFS-31587

User's Guide for ENSAERO

Ames Research Center, Moffett Field, California

A report summarizes the development, applications, and procedures for use of ENSAERO, a computer program for simulating aeroelastic phenomena (e.g., wing flutter) of aircraft and spacecraft. ENSAERO computes aeroelastic responses by simultaneously numerically integrating Euler and/or Navier-Stokes equations of airflow and modal finite-element equations of structural dynamics on aeroelastically adaptive dynamic grids. The numerical integrations are performed by time-accurate finite-difference schemes. The report describes the coupling of the governing equations of flow with the governing equations of structural dynamics and with equations that describe active controls and thermal loads. The criteria and procedures for generation of zonal adaptive grids are discussed. Results of simulations performed by use of ENSAERO are presented for examples that involve, variously, steady or unsteady flow about rigid full aircraft or elastic wing/body assemblies.

This work was done by Guru P. Guruswamy of **Ames Research Center**. *To obtain a copy of the report, "User's Guide for ENSAERO-A Multidisciplinary Program for Fluid/Structural/Control Interaction Studies of Aircraft (Release 1)," access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Mechanics category.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Ames Research Center, (650) 604-5104. Refer to ARC-14239.

Minimally Actuated Hopping Robot

This robot can traverse terrain that is too cluttered for wheeled vehicles.

NASA's Jet Propulsion Laboratory, Pasadena, California

A small robot that travels by hopping has been built and tested. This is a prototype of hopping robots that would carry video cameras and possibly other sensory devices and that are under consideration for use in exploring cluttered, unpredictable terrain on distant planets. On Earth, robots like this one might have value for entertainment and civilian and military reconnoitering of hazardous areas.

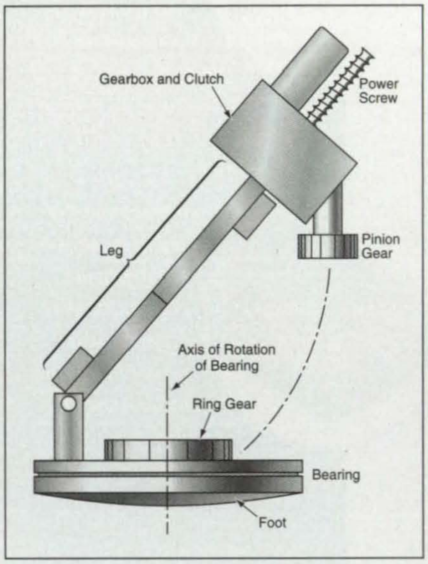


Figure 1. The **Steering Mechanism** and its geometric relationship with the tilted assembly are depicted here in simplified form. The self-righting mechanism and some other components are omitted for clarity.

The design of this robot is a compromise between functionality on the one hand and simplicity, reliability, and lightness of weight on the other hand. The robot is said to be minimally actuated in that all motions are generated by use of a single motor that drives several mechanisms.

The robot (see Figure 1) includes a foot, a bearing on the foot, and a tilted assembly that contains the rest of the robot. The tilted assembly can be pivoted on the bearing to pan the camera and to steer the robot for the next hop. The tilted assembly includes an extendable leg that contains a spring and an associated linkage for extending and retracting the leg. To store energy for the next hop, the motor drives a power screw that compresses the spring and retracts the leg. At the desired moment of hopping, the motor actuates a mechanism that releases the spring, which then rapidly extends the leg to generate the hopping motion. The spring and linkage are designed together to make the extension force a nonlinear function of displacement that maximizes the proportion of spring-compression energy converted to hopping kinetic energy.

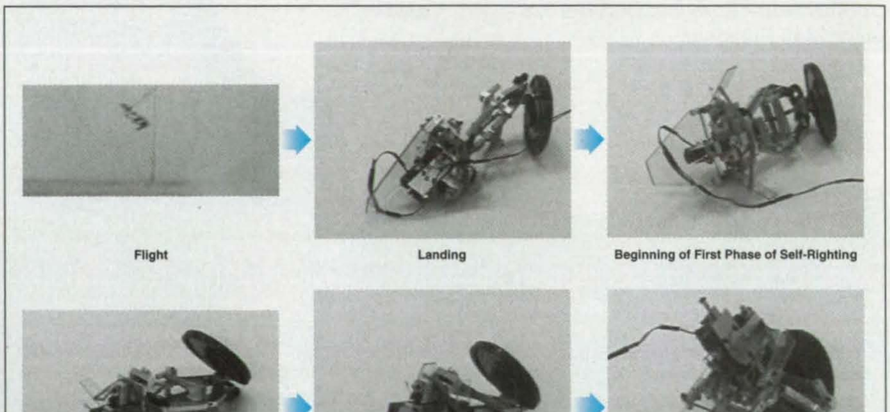


Figure 2. The **Robot Rights Itself** after hopping and landing toppled over.

The masses of the components are distributed so as to make the robot bottom-heavy for stability when it sits upright on the foot with its main assembly tilted and the leg compressed in preparation for hopping. Because the robot can be expected to lie toppled over after most hops, a self-righting mechanism is included. The self-righting mechanism deploys flaps to push the robot to the stable upright orientation.

To take advantage of minimal actuation, it is necessary to perform most operations sequentially rather than simultaneously. Hence, the robot must operate in cycles. To enable the single motor to effect the desired sequence of motions, the motor is coupled to the various actuator mechanisms by use of a variety of coupling mechanisms that include an overrunning clutch and timing and logic mechanisms. The sequence of motions during one cycle is the following:

1. Assuming that the robot has just landed from the preceding hop, the self-righting mechanism is actuated in a two-phase operation.
2. During the second phase of the self-righting operation, the spring is compressed and the leg retracted in preparation for the next hop. Because retraction of the leg restores the bottom-heavy configuration, it aids self-righting. Figure 2 depicts a sequence of events from flight through landing and self-righting.
3. The spring is locked in compression to prevent premature hopping.
4. The tilted assembly is rotated to steer for the next hop and to pan the camera.
5. The spring is released to make the robot hop.

This work was done by Paolo Fiorini, Joel Burdick, Eric Hale, and Nathan Schara of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Machinery/Automation category.*
NPO-20911

Mobile Robot With Foveal Machine Vision

Lyndon B. Johnson Space Center, Houston, Texas

The Foveal Extra-Vehicular Activity Helper-Retriever (FEVAHR) is a mobile robot that features a hierarchical foveal machine-vision system (HFMV). The FEVAHR is a prototype of future robots that could detect, recognize, track, and pursue objects and avoid obstacles while operating autonomously, controlled by human operators via natural-language commands, or both. The design of the FEVAHR merges high- and low-level anthropomorphic designs. The high-level anthropomorphism is represented by (1) the Semantic Network Processing System (SNePS) software for semantic representation of information, inference, and natural-language interaction, and (2) the Grounded Layered Architecture With Integrated Reasoning (GLAIR) software, which acts as an interface between SNePS on the one hand and subconscious processes and sensors on the other hand. The low-level anthropomorphism is represented by the HFMV hardware and software, which exploit the neuromorphic multiacuity sensing and information processing prevalent among vertebrates to achieve an effective visual information-acquisition power that is higher than that of uniform-acuity active vision. SNePS, GLAIR, and HFMV work in unison, each driving and being controlled by the others, to accomplish physical tasks with constrained resources and maintain a high level perception necessary for autonomous interaction with humans.

This work was done by Andrew Izatt, Christopher A. Kramer, Cesar Bandera, and Fenglei Du of Amherst Systems, Inc., and Stu Shapiro and Henry Hexmoor of the State University of New York for **Johnson Space Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Machinery/Automation category.*
MSC-22995

Rotary Tool and Retractable Foot for Walking Robot

One end effector alternates between two roles.

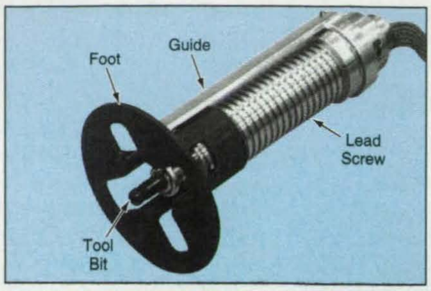
NASA's Jet Propulsion Laboratory, Pasadena, California

A mechanism has been developed to serve as an end effector for one of the legs of the Legged Excursion Mechanical Utility Robot (LEMUR) — a walking robot designed for demonstrating robotic capabilities for maintenance and repair. [The LEMUR was described in "Six-Legged Experimental Robot" (NPO-20897), *NASA Tech Briefs*, Vol. 25, No. 12 (December 2001), page 58.] Through controlled actuation of this mechanism, the tip of the leg can become either (1) a foot for stable support during walking or (2) the robotic equivalent of a simple hand tool — a ball-end hexagonal driver for a standard hexagonal-socket machine screw. More specifically, the foot can be extended to enable walking, or can be retracted to enable cameras that are parts of the robot to view the insertion of the tool bit in a

socket. Retraction of the foot also enables the tool to be used in confined spaces in which the foot cannot fit.

The mechanism (see figure) includes a hollow lead screw. The foot includes a nut that engages the lead screw. A compact, lightweight motor with a speed-reducing, torque-multiplying gear head is housed inside the lead screw. An external guide prevents rotation of the foot when such rotation is not desired. In preparation for retraction of the foot, the guide is initially locked against rotation of the foot by use of a pin and slot that mate in only one position. When the motor rotates the lead screw in one direction, the foot is retracted along the lead screw, exposing the tool bit.

When an axial compressive force is applied to the tool (as when the tool bit is inserted in a socket in a machine screw), interface pins between the tool bit and the guide transmit some of this force to the guide, thereby pushing the guide out of the slot that locks it and the foot against rotation. Now the guide and foot begin to rotate along with the lead screw and retraction of the foot ceases. Because the tool bit is mated with the lead screw in such a way that when the lead screw is rotating, the bit is also rotating, the lead screw can now be rotated in either direction to cause the tool to rotate the socket and thereby tighten or loosen the machine screw. The output torque of the motor, and hence the torque applied to the machine screw, is governed by a current-feedback motor controller.



This **Mechanism** is designed to be mounted on the outer end of one leg of a walking robot. The foot can be retracted to expose the tool bit, or extended to enable the robot to walk.

Once the tool is relieved of the axial compressive force (as when the tool bit is removed from the socket), the guide and foot continue to rotate until the pin engages the slot. At this point, the guide and foot are once again constrained against rotation; hence, rotation of the lead screw in the appropriate direction causes extension of the foot, restoring the walking configuration.

This work was done by Jennifer Knight and Stephen Askins of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at*** *www.nasatech.com/tsp under the Machinery/Automation category.* *NPO-30276*

Minirovers as Test Beds for Robotic and Sensor-Web Concepts

These units would be highly functional, robust, repairable, and reprogrammable.

NASA's Jet Propulsion Laboratory, Pasadena, California

The figure depicts a proposed reconfigurable miniature exploratory robotic vehicle (minirover) that would serve as a versatile prototype in the development of exploratory robots and "smart"-sensor systems that contain them. For example, minirovers could serve as nodes of sen-

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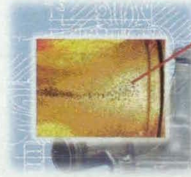
Honeywell's Corrosion Inhibitor Extends the Life and Improves the Performance of Aluminum Pumps



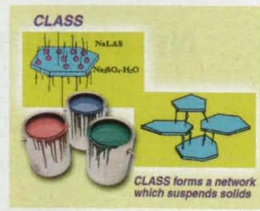
Diesel engine cylinder wall corrosion caused by cavitation

Cavitation-erosion corrosion occurs when tiny bubbles form under pressure in aluminum pumping systems and collapse with such force they erode the soft metal. This action can damage, even destroy, pump components in automotive water pumps and industrial and commercial heating/cooling systems.

Most conventional corrosion inhibitors are highly toxic and major automotive manufacturers have required many corrosion inhibitors to be organic. Acid-based organic corrosion inhibitors such as mono- and di-carboxylic acids were developed and proved useful for protecting against general types of corrosion but less effective against CE corrosion.

Honeywell has developed an organic CE corrosion inhibitor under the Prestone name that improves the effectiveness of carboxylic acids by adding polymerizable-acid graft polymers. This effective inhibitor also aids lubrication and is being successfully used in automotive antifreeze coolants, with potential for industrial and commercial heating/cooling systems.
http://www.yet2.com/nasatech/223

Novel Thickening Agent Promises Better Stability, Faster Processing, and Easier Clean-up



CLASS forms a network which suspends solids

Traditionally, products such as inks, paints, and coatings have been thickened with materials that can separate easily, be unstable, and be highly sensitive to any formula variation. **Procter & Gamble** has developed a novel, water-soluble thickening agent for a broad range of compounds and coatings offering a number of advantages over conventional thickeners, including:

- Improved viscosity stability, even at high temperatures
- Greater formula flexibility
- Superior suspension of heavy materials
- Easier processing through simple dispersion
- Better anti-sag/anti-settling properties
- Water-soluble for easy clean-up

http://www.yet2.com/nasatech/220

Improved Smart Card Technology for High Capacity Mobile Storage Applications

Bayer AG has developed a suite of technologies combining short-term alphanumeric data storage and retrieval with long-term image data storage, all in a convenient, secure, credit card-type format.

Electronic chip storage is used to hold temporary files of, say, daily blood pressure and heart rate measurements for medical patients. The patients' long-term records, including scans, X-rays, and other graphical data, could all be held in the optical storage portion of the card. Daily records could be periodically downloaded for use, then moved to the long-term storage portion, freeing up the short-term storage for new records.

To protect privacy, Bayer AG uses security and validation codes to limit access. This high capacity memory card technology supports many applications, including medical documentation, shipping, remote test and measurement, insurance, corporate and military personnel records, and much more.
http://www.yet2.com/nasatech/222

Pressure-Sensitive Paint Offers Significant Advantages for Wind Tunnel Testing

BAE Systems Advance Technology Centre

Traditional wind tunnel testing requires expensive, time-consuming modeling and embedded sensors, but BAE has developed a new way of measuring both surface pressure and temperature using just pressure-sensitive paint and laser excitation to provide results in a fraction of the time required by conventional testing. BAE's technology is based on oxygen concentration levels and uses fluorophore organic dyes and a gas permeable paint suitable for a number of surfaces, including metals, glass, and plastic.

The sensing system is unaffected by ambient light, enabling field condition testing in some cases. The scanning and A/D conversion equipment features off-the-shelf electronics and computers – no elaborate sensor-embedded model construction is needed.

BAE's technology also holds promise for a variety of applications in which oxygen concentration is key, including oxygen sensing for food package testing, pharmaceutical testing and environmental monitoring.
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A **Reconfigurable Minirover** would have approximately the size and shape of a football. It would comprise modules that could readily be added, removed, or replaced to effect repair or reprogramming.

sor webs — networks of spatially distributed autonomous cooperating robots — that have been contemplated for use in exploring large areas of terrain. [The concept of such networks was reported in more detail in "Sensor Webs" (NPO-20616), *NASA Tech Briefs*, Vol. 23, No. 10 (October 1999), page 80.]

To be suitable for incorporation into a sensor web, a minirover must be small, lightweight, inexpensive, capable of multifunctional radio communication and of operating on minimal power, and adaptive in functionality. It has been conjectured that in order to satisfy these requirements, it will be necessary to design each node of a sensor web to have specialized capabilities, and that it would be necessary to incorporate nodes having different capabilities to build the network into a system capable of performing the tasks required of it.

A minirover according to the proposal would serve as a test bed for the integration of component technological concepts into the design of a system at both the individual-sensor and the "smart"-sensor-web levels. Advances in propulsion, sensors, materials, microelectronics, and micromanufacturing offer the potential for the economical construction of future small rovers and other autonomous vehicles, which, when deployed as a team, would exhibit behaviors characterized by the complexity, adaptability, and flexibility, of larger, single mobile robots that have been used previously.

Because one of the key design requirements for the proposed reconfigurable minirover is portability by a single human, its target design weight is 10 to 20 lb (corresponding to a mass between about 4.5 and 9 kg) and its target design footprint is 20 by 40 cm (about the size of a football). The design would be characterized by modularity, decoupling, flexibility, and simplicity. Simplicity would minimize the number of failure modes and make it possible to use uniform repair techniques. Decoupling would reduce the likelihood that failures of single components would cause failures of the entire rover or of the sensor web as a system. Flexibility would make it possible to use a small number of spare parts and/or software modules that could be connected in various ways to repair, rebuild, and/or reprogram the minirover.

Among the components of a reconfigurable minirover would be a mechanical frame, a strong, lightweight mast that could be folded into a small storage space, a computer, microcontroller, wireless modems, battery, a vision subsystem, and a bay in which scientific instrumentation would be installed. The mobility system of the minirover would include two drive shells that would act as wheels, driven by a motor and gearhead. The shells could be pushed apart, when required, to deploy a scientific instrument or extend the mast.

The main advantage of the two-wheeled design is the potential for mechanical robustness. Either an off-axle center of mass or a dragged tail would be used to create the necessary reaction torque. The tailless version would be more maneuverable on flat ground, while the tailed version would offer the greater reaction torque needed to traverse a steep slope. It would be easy to "armor" such a rover against impact, enabling such novel operations as ballistic deployment and imparting a high tolerance of impacts (such as those of falling off cliffs) caused by navigational errors.

This work was done by Ashitey Trebi-Ollennu and Brett Kennedy of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Machinery/Automation category.*
NPO-30342

Tool for Installing a Seal Ring Between Pipe Flanges

Sealing surfaces are kept clean and injuries to fingertips are prevented.

Stennis Space Center, Mississippi

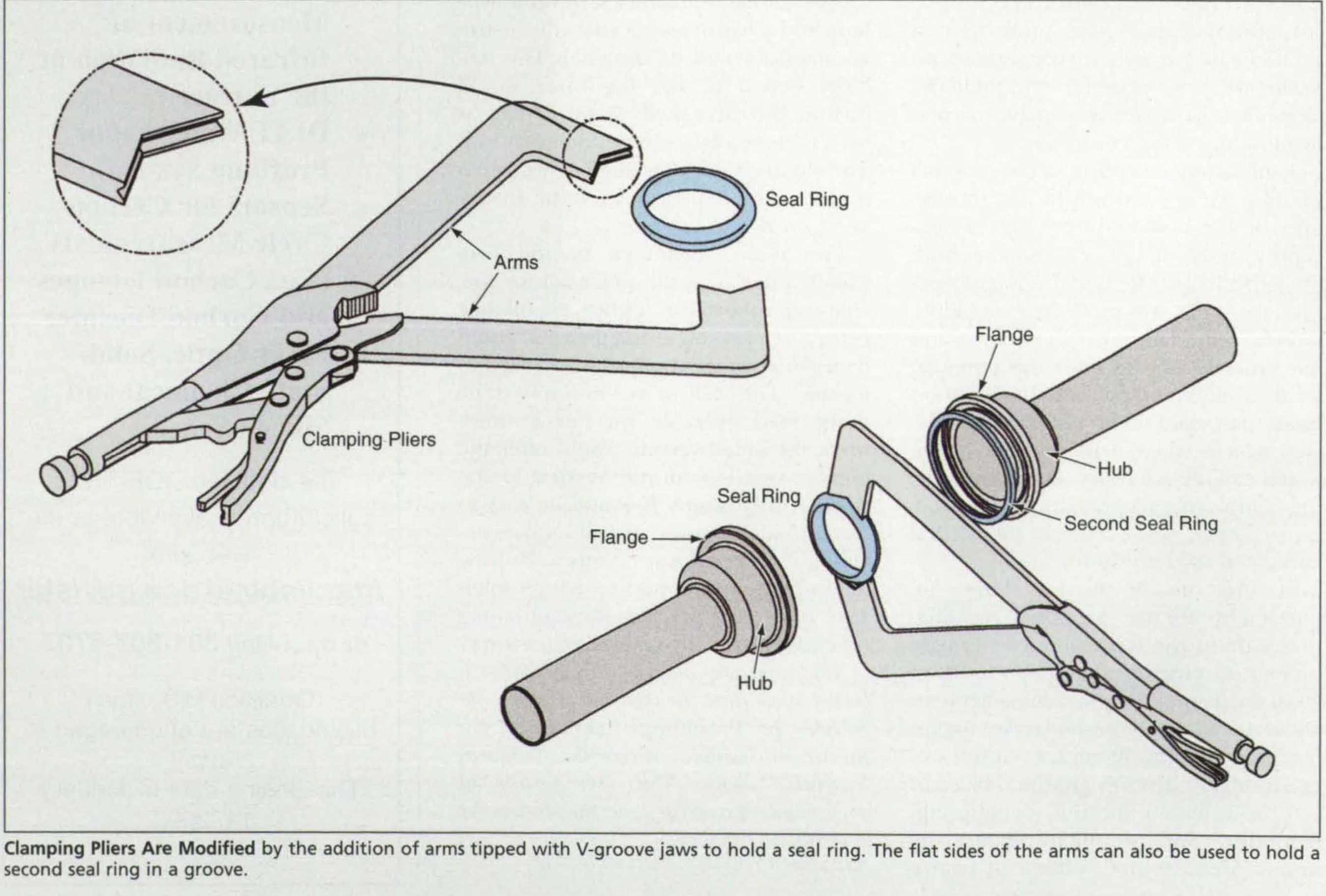
A tool has been devised to facilitate the accurate placement of a seal ring between the hubs of two pipe flanges that are to be clamped together. Heretofore, technicians have resorted to improvisations that have included, variously, insertion of a ring with fingertips, lowering a ring into place by use of string or tape, sticking a ring to one hub by use of grease while the other hub is brought into alignment, and/or positioning a ring by use of a screwdriver or knife. All of these improvisations entail susceptibility to incorrect placement of the ring and contamination of sealing surfaces. Moreover, by inserting fingertips in the narrow pinch gap between the hubs, a technician risks injury.

The present tool makes it possible to position the seal ring accurately, without risking either contamination of sealing surfaces or pinch injuries to fingertips. The tool accommodates a wide range of seal-ring diameters and a variety of seal cross sections. It can be adjusted to the proper starting diameter and made to clamp the seal ring gently but securely so that it holds the seal ring until it has been properly placed. Once the ring has been clamped by the tool, the ring can be installed between the pipe-flange hubs, set aside, or handed to another technician, all without releasing the ring. Once the seal ring has been installed between the hubs and the hubs have been positioned for final clamping, a slight force on one tool handle initiates the release of the seal ring from the tool, and the tool can then be withdrawn.

The tool (see figure) consists of a pair of locking pliers to which a pair of integral or separable arms have been added. The mutually facing ends of the arms are tipped with V-groove jaws that are angled to hold the seal ring securely. If the arms are separable, then there can be multiple pairs of arms, each pair optimized for a particular range of seal-ring diameters and/or cross sections. If necessary, the flat sides of the arms can be used simultaneously to hold a second, larger-diameter seal ring in a groove in one of the hubs while the jaws of the tool hold a first seal ring as described above.

This work was done by L. Haynes Haselmaier, Sr., of Mississippi Space Services for **Stennis Space Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Manufacturing category.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Stennis Space Center; (228) 688-1929. Refer to SSC-00120.



Clamping Pliers Are Modified by the addition of arms tipped with V-groove jaws to hold a seal ring. The flat sides of the arms can also be used to hold a second seal ring in a groove.

Locating Epileptic Foci by ANN Analysis of Interictal Spikes

Surgical implantation of subdural electrodes would no longer be necessary.

NASA's Jet Propulsion Laboratory, Pasadena, California

A diagnostic software system (DSS) now under development is intended to implement artificial neural networks (ANNs) that will analyze magnetoencephalographic (MEG) data to locate foci and epicenters of epileptic activity in human patients. This DSS is applicable to single-focus epilepsy, in which a seizure is caused by uncontrolled firing of neurons that starts from a single location in the brain (the focus) and spreads across the brain like an electrical storm.

Depending on the specific form of single-focus epilepsy, it may be possible to effect a cure through surgical removal of a small volume of brain tissue that contains the focus. Accurate determination of the locations of the epicenter and focus is prerequisite to this surgery. Heretofore it has been standard procedure to determine these locations in a two-stage process in which (1) surface electroencephalographic (EEG) data are collected by use of surface electrodes to locate the epicenter approximately, then (2) EEG data are collected by use of a network of surgically implanted subdural electrodes to record data during multiple seizures to locate the focus and epicenter precisely. The main goal in the present development of a DSS is to eliminate the surgical implantation of electrodes and the associated discomfort, risk of infection, and long hospitalization (typically a month or more).

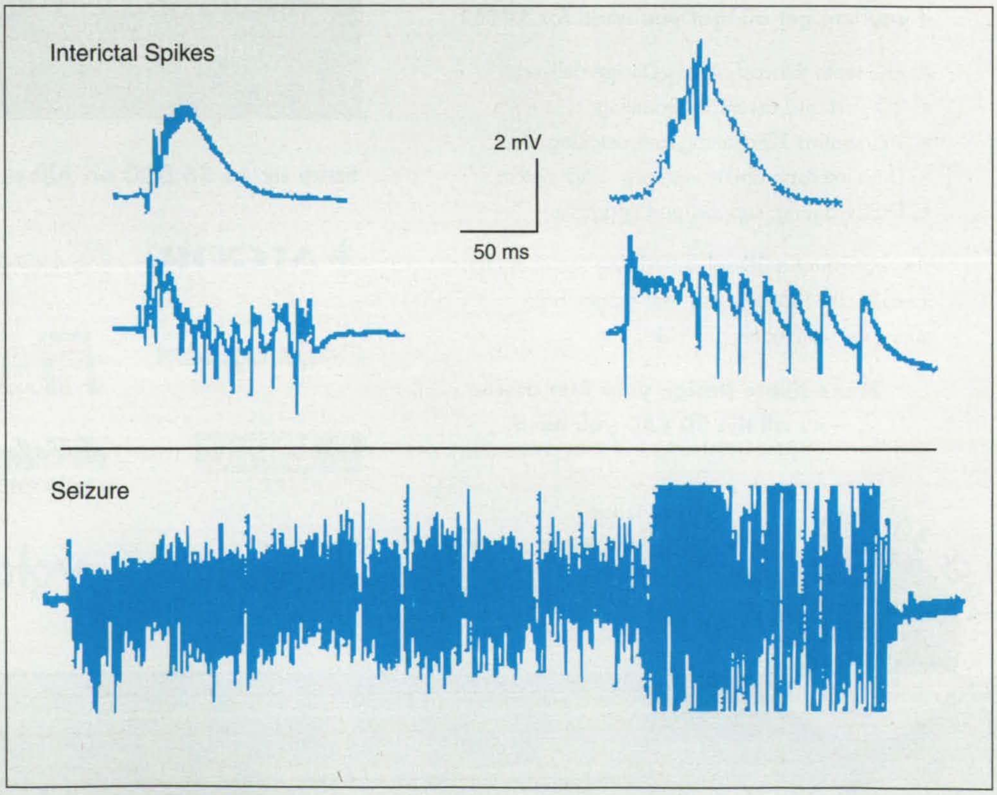
The DSS is intended to recognize and analyze interictal spikes (IIS), which are large, slow pulses that occur in MEG and EEG signals of single-focus epilepsy patients during the intervals between seizures. Because these pulses occur between seizures, they can be observed against a relatively calm background. They originate from the same focus as that of seizures, propagate across the brain in a predictable fashion, and have known shapes (see figure).

Typically, MEG signals are acquired at hundreds of locations on the surface of the head. When fully developed, the software would implement several cooperative ANNs that would analyze the multiple digitized signals. Each ANN would respond to one of several key attributes of IIS. This architecture of cooperative neural networks, each network responding to one and only one attribute of an observed target, is patterned on the mammalian visual cortex, in which one area responds only to color, another area responds only to edges, another only to movement, and so forth.

In the DSS, one ANN would respond only to the shapes of IIS, one would respond only to the frequency of IIS, one would respond to the direction of propagation of IIS, and one would respond to differences between signals recorded during waking and sleeping. The shape, frequency, and direction networks would all contribute to locating the focus and epicenter. The waking/sleeping network would determine whether or not the IIS pattern changes between waking and sleeping. No change is indicative that the area that contains the epicenter is "scarred" — that is, disconnected from the rest of the brain because of the epilepsy. Knowledge of such scarring can be useful in planning the surgical resectioning.

This work was done by Charles Hand of **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Bio-Medical category.*

This software is available for commercial licensing. Please contact Don Hart of the California Institute of Technology at (818) 393-3425. Refer to NPO-30211.



This **Collection of MEG Signals** includes four typical interictal spikes, which are clearly distinguishable from a seizure signal.

Physical Sciences

Electrostatic/Electrodynamic Nanoparticle-Capture Vessel

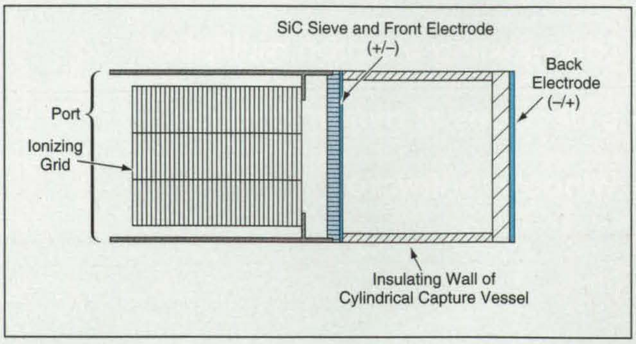
Particles could be sampled under remote or automatic control in harsh environments.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed simple, portable, robust apparatus, capable of automated operation, has been proposed for collecting samples of selected biological or chemical species in harsh environments. The sampled species could range in size from molecules to nanoparticles (that is, particles with dimensions of the order of nanometers). The apparatus would select a biological or chemical species of interest for sampling by utilizing a combination of (1) electrostatic or electrodynamic fields and (2) a sieve containing holes of predetermined size.

The apparatus (see figure) would include an ionizing grid, the sieve, an electrically insulating capture vessel, and a back electrode at the far end (the right end in the figure) of the capture vessel. The sieve would consist of a porous disk of silicon carbide on silicon, supported by an electrically insulating ceramic ring that would be sealed to the left end of the capture vessel. The sieve would contain an array of nanopores formed by a photoelectrochemical etching process. The nanopores would be made to taper toward narrower openings on the capture-vessel side. A metallic film could be deposited on a surface of the SiC sieve for electrical contact.

In operation, entering particles would be ionized by use of static or pulse discharges in the ionizing grid. An electric potential would be applied to the sieve, causing the ionized particles to accelerate toward and through the sieve. The opposite potential would be applied to the back electrode. Particles would be selected for passage according to their sizes and the sizes of pores in the sieve. After passing through the sieve, the particles would be decelerated by the electric field between the sieve and the back electrode. Condensable molecules would be collected on the inner surface of the capture vessel. Data sampling can be accomplished remotely by spectrographically imaging a thin-film silicon carbide port incorporated into the middle of the backplane.



Particles Would Be Ionized, filtered through nanopores, and decelerated by an electric field in the capture vessel.

This work was done by Margaret Ryan, Virgil Shields, and Roger Williams of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Physical Sciences category.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

Intellectual Property group
JPL
Mail Stop 202-233
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-2240

Refer to NPO-30182, volume and number of this NASA Tech Briefs *issue, and the page number.*

Radiometer for Measuring Cirrus-Cloud Ice and Water Vapor

Accurate measurements would contribute to understanding of weather and climate.

NASA's Jet Propulsion Laboratory, Pasadena, California

An airborne submillimeter-wavelength radiometer, expected to be built and tested in the near future, is designed primarily to yield measurement data that can be processed to quantify the ice contents and mean sizes (and, to some extent, the shapes) of ice crystals in cirrus clouds that range from optically thin to opaque. Secondarily, this radiometer is also designed to enable the characterization of water-vapor profiles in the presence of optically thick clouds. The ice and water-vapor data are needed to improve understanding of processes that affect weather and climate.

Submillimeter-wave cloud-ice radiometry is a relatively new technique that originated in two theoretical studies published in 1995. These studies showed that (1) cirrus ice particles scatter upwelling radiation emitted by water vapor in the lower troposphere; (2) this effect makes the clouds look radiatively cold against a warm emission background; and (3) the ability of cirrus ice to scatter radiation is primarily a function of the ice content and the distribution of crystal sizes. Accordingly, submillimeter-wavelength cloud-ice radiometry is based on the proposition that by measuring submillimeter-wavelength radiation at two widely separated frequencies, it should be possible to distinguish between changes in scattering of radiation induced by changes in median crystal size and changes in scattering induced by changes in the total ice content.

The radiometer now under development will be used to verify the theoretical studies and demonstrate the principle of cloud-ice radiometry. A notable part of the development has been the design of a 325- and a 448-GHz receiver, both capable of taking measurements to within

1 GHz of their local-oscillator frequencies, as needed to optimize retrieval algorithms. Earlier proof-of-concept measurements by use of other radiometers did not provide corrections for water vapor. This instrument is designed to provide much higher accuracy, including, when applicable, providing the data needed to correct for water vapor.

This work was done by Erich Schlecht, Imran Mehdi, Lorene Samoska, Paul Batelaan, Peter Siegel, Steven Walter, Robert Ivlev, Robert Losey, Trong-Huang Lee, Kent Evans, and Jose Guerrero of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Physical Sciences category. Refer to NPO-21081*

System For Measuring Osmotic Transport Properties of a Membrane

Membrane-testing operations are performed automatically.

Marshall Space Flight Center, Alabama

The membrane test cell (MTC) is an automated laboratory apparatus that applies a known osmotic potential across a membrane and measures the kinetics of the resulting transport of solvents across the membrane as a function of time. Data acquired by use of the MTC should prove especially helpful in designing industrial processes that rely on membrane separation techniques. Examples of such processes include desalination, recovery of designated chemicals from process streams, and some recycling operations.

The MTC includes two fluid chambers separated by the membrane under test, volumetric flow sensors connected to the chambers, a fluid-manipulation subsystem consisting of pumps and valves, a computer, and electronic circuits that serve as control and data-acquisition interfaces. The chambers, the fluid-manipulation subsystem, and the associated plumbing are designed to contain the fluids of interest and to enable automated filling and draining of the chambers without trapping of bubbles. The chambers can be taken apart at the membrane seal to replace the membrane. The computer runs software that controls the fluid-manipulation subsystem and acquires kinetic data from the volumetric flow sensors for characterization of functionality of the membrane.

At the beginning of a test, the fluid-manipulation subsystem introduces solutions of differing chemical potential (known different compositions) into the chambers. This filling operation is performed quickly in order to enable precise definition of the starting time. A solute-outflow sensor signals when the solute cell (one of the chambers) is full and initiates the data-acquisition functions. The fluid in the solute cell is stirred during the test to prevent stratification and thereby provide a relatively constant chemi-

cal potential to drive transport through the membrane. The volumetric flow sensors measure the relative volumes of fluids in the chambers as functions of time. The volume-vs.-time data, which are directly related to the kinetics of osmosis, are recorded in a data file in the computer and displayed on the computer screen. The volume measurements can be differentiated with respect to time to determine flow rates as a function of time. The volume-vs.-time data can also be processed to determine the permeability and flow characteristics of the membrane as functions of known driving potential and of time.

A new membrane can be characterized by use of the MTC and thereafter the membrane can be tested at intervals throughout its functional lifetime to identify gradual changes in its kinetics. Such changes can be indicative of fouling, leakage, and other effects associated with deterioration.

A collaboration among Lockheed Martin Astronautics, NASA, the National institute of Standards and Technology (NIST), and the Federal Bureau of Reclamation began in 1997, when a prototype MTC was developed and characterized. Results from experiments on the prototype MTC have shown that the MTC is useful for characterizing the performances of membranes and can be used to differentiate among various deterioration processes.

This work was done by Larry W. Mason of Lockheed Martin and John Peleigrino of NIST for **Marshall Space Flight Center**. *For more information, contact the Marshall Commercial Technology Office at 256-544-2615.*
MFS-31566

Vacuum Leak Detection Using Piezoelectric Film

John F. Kennedy Space Center, Florida

A technique for detecting a small leak of gas into a vacuum involves the use of a diaphragm made of a thin film of poly(vinylidene fluoride) [PVDF]. To exploit the piezoelectricity of PVDF for this purpose, both sides of the film are coated with thin, electrically conductive layers that serve as electrodes. Wires connect the electrodes to the input terminals of a buffer amplifier and associated circuitry that measures the voltage induced between the electrodes by the piezoelectric effect in the film. In operation, the diaphragm is moved around in the vacuum in the vicinity of, and facing toward, a suspected leak. When the diaphragm crosses the stream of leaking gas, the pressure of the gas impinging on the diaphragm bends the diaphragm, thereby inducing a voltage. In an experiment, a prototype sensor based on this concept generated a signal of about 60 mV from air leaking into a vacuum through an orifice 10 μm wide at a rate of 0.017 standard cm^3/s. The noise floor of the sensor was found to be about 5 mV. It was concluded that even this initial unoptimized sensor should be able to detect leaks somewhat smaller than 0.01 standard cm^3/s.

This work was done by Robert C. Youngquist of **Kennedy Space Center** *and William Haskell and Robert Cox of Dynacs, Inc. For more information, contact the Kennedy Commercial Technology Office at 321-867-8130.*
KSC-12244/026

Information Sciences

An Off-Line FQPSK-B Software Receiver

This software affords flexibility for evaluating alternative designs at relatively low cost.

NASA's Jet Propulsion Laboratory, Pasadena, California

Software that performs the functions of an FQPSK-B receiver (and to some extent, an FQPSK-B transmitter) has been developed to reduce the risks and costs associated with the development of hardware FQPSK-B transmitters and receivers. ("FQPSK-B" signifies version B of Feher Quadrature-Phase-Shift Keying, which is a patented, bandwidth-efficient phase-modulation scheme named after its inventor. FQPSK-B includes filtering, beyond that of FQPSK, for further containment of the modulation spectrum.) This software can be especially helpful to engineers who are considering the use of FQPSK-B for bandwidth-efficient, high-data-rate digital communications.

The FQPSK-B software receiver is an off-line coherent receiver that can be used as a stand-alone FQPSK-B receiver or as a means of testing and evaluating hardware FQPSK-B receivers, transmitters, and transceivers. The software can be customized for testing and validating hardware FQPSK-B transceivers under consideration for purchase. To satisfy requirements pertaining to testing, the receiver contains an internal reference transmitter and a simple additive-white-Gaussian-noise (AWGN) channel; hence, the software receiver can also be used as a test bed for end-to-end simulations of FQPSK-B communication systems.

The software consists of many modules that perform diverse functions, including differential encoding, generation of FQPSK waveforms, modulation, AWGN channel model, carrier and symbol synchronizations, coherent demodulation and detection, differential decoding, real-time performance monitoring, and postprocessing of data to generate results of tests. The modules can be configured to carry out specific tasks in each of four different modes of operation of the receiver.

The software receiver was developed on a Sun workstation by use of the Matlab version 5.3 technical-computing software with such Simulink software libraries as the Communication Toolbox and the DSP Toolbox. The software receiver can be implemented on computers that utilize such operating systems as UNIX, Windows, and MacOS, as long as proper versions of Matlab/Simulink are installed. Moreover, because of the similarity between FQPSK and other phase-modulation schemes in the QPSK family, the software can readily be modified to accommodate those schemes.

This work was done by Haiping Tsou, Scott Darden, and Tsun-Yee Yan of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Information Sciences category.*

This software is available for commercial licensing. Please contact Don Hart of the California Institute of Technology at (818) 393-3425. Refer to NPO-21050.

Update on Web Interactive Training

Customized training in diverse subjects is delivered to trainees automatically, on demand.

John F. Kennedy Space Center, Florida

The Web Interactive Training (WIT) project at Kennedy Space Center has expanded its course offerings, enhanced its technical capabilities, and automated its administrative functions. Aspects of the WIT project at previous stages of development were reported in "Further Developments in Web Interactive Training" (KSC-11962), *NASA Tech Briefs*, Vol. 24, No. 1 (January 2000), page 52. To recapitulate: WIT delivers training to client desktop computers on demand.

The following WIT developments are particularly noteworthy:

- A WIT course offers training in the basics of ultrasonic testing. Topics include the basic physics of sound, typical ultrasonic-testing equipment used at Kennedy Space Center, and several testing methods. The course also includes an interactive simulation in which the trainee learns to perform a basic shear-wave calibration of an ultrasonic instrument.
- Another WIT course provides training in the design and analysis of single- and multi-factor experiments and prepares the trainees for a formal graduate course in the design of experiments. The course covers such basic concepts of the design of experiments as randomization, replication, testing of hypotheses, and confidence intervals. After receiving instruction, a trainee performs "hands-on" analysis of several different types of experimental designs, including those of two independent samples, paired comparison, complete randomized design, randomized complete block design, Latin-square design, and two-factor design.
- An integrated Wed-based application program largely automates the registration, testing, and maintenance of records of WIT trainees. The program provides for two user levels: trainee and administrator. A trainee fills out a short registration form, and the system automatically assigns the student an identification number and verifies the information through electronic mail. When the student logs into the system, he or she can take any of the available courses, track his or her own progress, update student information, change passwords, and evaluate the courses. When an administrator logs into the system, he or she can (in addition to exercising all student-level

privileges) track the progress of a student, review student registrations and course evaluations, edit and add quizzes, and review and analyze quiz metrics. Quizzes are randomly generated from a database of questions. The number of questions to be drawn for each quiz can be set by the administrator. Therefore, each student should get a different set of questions each time he or she takes the quiz. Upon taking the quiz, the student gets immediate feedback on each question, including an explanation of the answer and a link back to the relevant part of the course.

The software that administers the WITS courses was developed by use of commercial off-the-shelf Web-development software. The WIT course software resides on a Windows NT server computer that runs the Microsoft Internet Information Server 3.0 and Cold Fusion Application Server 4.0 software.

This work was done by Thomas Brubaker, Angela Smibert, David Penca, Sergei Kossenko, and Lawrence W. Haines of Dynacs Engineering Co. Inc. for **Kennedy Space Center**.

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

Dynacs, Inc.
Digital Media Lab
Kennedy Space Center, FL 32899

Refer to KSC-12159, volume and number of this NASA Tech Briefs *issue, and the page number.*

Refer to KSC-12159.

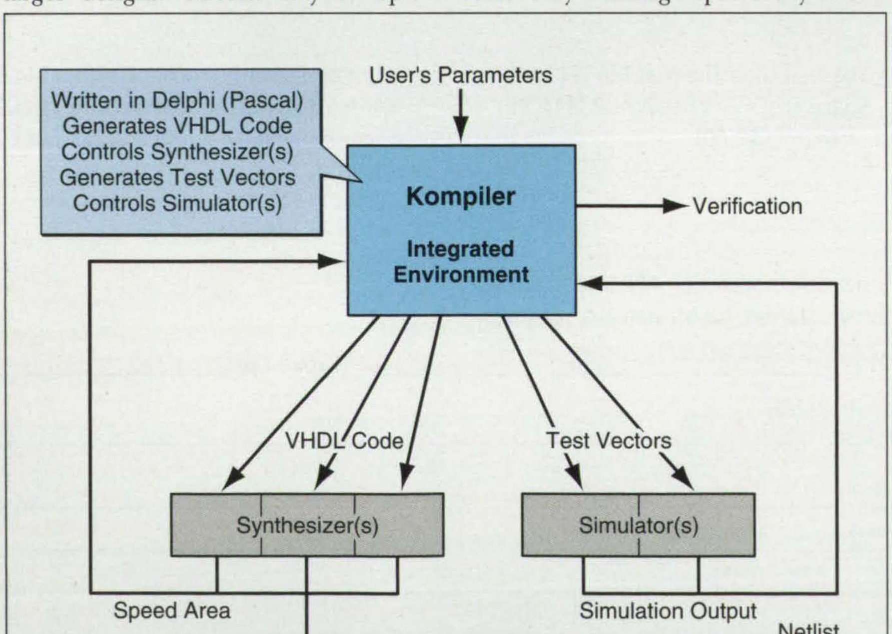
Methodology and Software for Designing Data-Processing ICs

A main goal is to reduce labor and errors in the design process.

Goddard Space Flight Center, Greenbelt, Maryland

A methodology and software to implement the methodology are under development in an effort to automate at least part of the process of designing integrated-circuit (IC) chips that perform complex data-processing functions. An important element of the methodology is reuse of prior designs, with modifications as required to optimize for a specific application. This minimizes a labor-intensive, error-prone part of the design process. The prior designs include what are known in the art as intellectual-property (IP) cores — that is, designs of functional blocks [e.g., random-access memories (RAMs), communications circuits, processors] that are incorporated into larger designs. Circuits may be optimized with respect to design goals, such as reducing chip size, reducing power consumption, and/or increasing radiation hardness.

The methodology is implemented by an extensible computer program denoted Kompiler (not to be confused with an identically named artificial-intelligence program mentioned in the computer literature dating back at least as far as 1955). Kompiler (see figure) affords capabilities for writing customized code in very-high-speed integrated-circuit (VHSIC) hardware description language (VHDL), with generation of test vectors, execution of synthesis, and simulation for verification. Generation of VHDL code for a functional block is performed by utilizing a previously coded generic software equivalent of a template (e.g., an IP core), the contents of which are embedded in the source code of Kompiler.



One Program generates code to specify and test an IC design.

Kompiler provides a user interface that enables selection of various options to satisfy the requirements of the particular application in which the functional block is intended to be used, while enabling a tradeoff between resources and features. For designing a read-only memory (ROM) or data-heavy component, input data are provided in the form of a specially formatted ASCII text file. Kompiler also affords options for selection of synthesis software and for choosing among coding styles, as coding styles can strongly affect the results of the logic synthesis. By use of these features of Kompiler, one can generate a customized version of the VHDL code of a generic functional block.

One of the initial applications and a complex test case for the Kompiler concept is the redesign of a commercial single-chip FPGA (field-programmable gate array) controller, denoted the AM29CPL154, that is radiation-soft, consumes high power by present standards, and is no longer manufactured. The redesigned version, denoted the 29KPL154, is intended to be radiation-hard, less power-hungry, and smaller, yet able to perform all the functions of the prior commercial version.

This work was done by Richard Katz of **Goddard Space Flight Center** *and Igor Kleyner. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Information Sciences category. For more information, contact the Goddard Commercial Technology Office at 301-286-5810.*

GSC-14379

Books & Reports

Quasi-Decoupling of Shvab-Zel'dovich Variables

A paper presents some novel conclusions concerning the Shvab-Zel'dovich (SZ) variables, which are linear combinations of dependent variables in mathematical models of multicomponent, chemically reacting flows. The SZ variables represent scalar quantities that are conserved, that is, are not affected by chemistry. The role of SZ variables is to decouple the conservation equations and make it simpler to solve them. However, SZ variables that entirely decouple the system of equations are generally defined only under the restrictive assumption that all Lewis numbers are unity (ALeU). Each Lewis number represents the ratio of a single species mass-diffusion characteristic time to the thermal conduction characteristic time. The present paper discusses the foregoing issues and further presents a mathematical analysis addressing the question of whether the ALeU assumption is a necessary condition for such decoupling. The conclusion reached in the analysis is that the ALeU assumption is sufficient but not necessary and that quasi-decoupling (that is partial decoupling) may be performed in the absence of thermal diffusion. When thermal diffusion is present, quasi-decoupling may still be performed subject to a controllable error.

This work was done by Josette Bellan of Caltech and Sau-Hai (Harvey) Lam of Princeton University for **NASA's Jet Propulsion Laboratory**. *To obtain a copy of the report, "On Decoupling of Shvab-Zel'dovich Variables in the Presence of Diffusion," access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Physical Sciences category.*
NPO-30515

Mechanism for Docking a Miniature Spacecraft

This report discusses a proposed docking mechanism to be located in a small hangar on the outside of the International Space Station (ISS). The mechanism would enable docking of a miniature robotic spacecraft (or free flyer) that would carry a video camera and would operate in the vicinity of the ISS. The docking mechanism would include, among other things, (1) an electromagnet for actuation, (2) electrical connectors for transferring data to and from the free flyer and recharging the free-flyer power system, and (3) a quick-disconnect (QD) coupling for recharging a supply of gaseous N_2. Once the free flyer had maneuvered into approximate docking alignment, an electromagnet in the mechanism would attract a ferromagnetic plate on the free flyer strongly enough to pull the free flyer in from a distance of as much as several inches ($\approx$10 cm). The mechanism would include surfaces that would mate with surfaces on the free flyer to correct any misalignment as the free flyer was pulled in. Once docked, the free flyer would be held in place by either spring-loaded cam locks or the QD coupling itself. Data, power, and N_2 can then be transferred to the vehicle.

This work was done by James David Jochim and Christopher S. Lovchik of **Johnson Space Center**. *To obtain a copy of the report, "Mechanically/Magnetically Actuated Docking and Refueling Mechanism for Satellite Servicing," access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Machinery/Automation category.*
MSC-23127

Emergency Tether-Deployment-and-Recoil-Mitigating Systems

A report describes an emergency tether-deployment (ETD) system designed to minimize the harm caused by two events that can occur during deployment of tethered payloads from a space shuttle in orbit. One such event is snagging of the tether during payout while the payload is near the shuttle, causing rebound of the shuttle and payload toward each, thus possibly causing a collision. The other event is recoil of a tether that must be cut while it is under tension. If not suppressed, the recoil can cause the tether to become tangled around the shuttle. The ETD system includes a tether wound on a spool in a standard pattern that minimizes friction during payout, plus a rotating-arm mechanism that prevents snagging. The ETD system can be either (1) used as a primary deployment system or (2) activated automatically through breakage of a tether tie-down in the event of a snag or when the payload is at a safe distance from the shuttle. To suppress recoil, a core of solder is inserted along part of the length of the tether. When a wave of recoil reaches this part, the solder absorbs most of the recoil energy.

This work was done by Andrew Santangelo of The Michigan Technic Corp. for **Marshall Space Flight Center**. *To obtain a copy of the report, "The Emergency Tether Deployer System and the Tether Recoil Mitigation System," access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Machinery/Automation category.*
MFS-31659

Analysis of Multilayer Thermal Insulation for Reentry

A paper presents a study of multilayer thermal insulations for protecting spacecraft against aerodynamic heating during reentry into a planetary atmosphere. A multilayer insulation considered in the study comprised (1) thin ceramic/composite foils coated with gold for high reflectance interspersed with (2) fibrous polycrystalline alumina spacers, all wrapped in (3) a bag made of ceramic fabric. The radiation heat transfer in the fibrous insulation spacers was modeled using the two-flux method assuming isotropic scattering. Combined radiative and conductive heat transfer in such blankets were computed by use of a finite-volume numerical model. The model was validated in steady-state and transient thermal tests of sample insulations.

This work was done by Kamran Daryabeigi of **Langley Research Center**. *To obtain a copy of the report, "Thermal Analysis and Design of Multi-layer Insulation for Re-entry Aerodynamic Heating," access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Materials category.*
LAR-16382

Assessing Energetic-Ion Effects Using Energetic Protons Only

Two reports describe a method of assessing the susceptibility of digital electronic equipment to upsets (bit errors) caused by impingement of energetic ions (both protons and heavier ions) in outer space. The method, which is applicable at the single-component, circuit-board, box, and total-system levels, involves terrestrial testing by use of 200-MeV protons only. Unlike in a prior method that involves lower-energy heavier ions, one need not place a test article in a vacuum or remove it from its normal packaging. One of the reports discusses the origin of the present method, describes the procedure for exposing various parts of a test article to an energetic-proton beam and analyzing the resulting test data to obtain radiation susceptibilities, and summarizes the experience gained by use of the method since its inception in the year 1995. The other report discusses mathematical modeling and development of software to estimate the effects of energetic heavier ions on the basis of testing by use of energetic protons only. Among the conclusions reached in this development is that the heavy-ion error rate can be estimated as an orbital-altitude-dependent fraction of the proton error rate.

This work was done by William X. Culpepper, Pat M. O'Neill, and Gautam D. Badhwar of **Johnson Space Center**. *To obtain copies of the reports, "Radiation Susceptibility Assessment of NASA/JSC Flight Hardware Using High Energy Protons" and "Software Development and Nuclear Interaction Modeling to Support Proton Testing," access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Physical Sciences category.*
MSC-23198 /99

New on the MARKET

Specialty Shaped Tubing

Eagle Stainless Tube & Fabrication, Franklin, MA, offers specialty shaped tubing, including teardrop, hexagonal, square, oval, and rectangular, among other shapes. Made of all 300 and 400 series stainless steel, nickel-based, and Inconel® alloys, the shapes are available in outer diameters from 1" to 0.060" and with a wall thickness down to 0.004". **For Free Info Visit www.nasatech.com/eagle**

High-Speed Camera

The OmniSpeed LR400 system from Speed Vision Technologies, San Diego, CA, combines a high-speed (slow motion) camera with the ability to record directly to high-capacity disks in a portable, ruggedized housing. The system is operated with a touchscreen LCD to access a Windows-based interface. Real-time viewing, recording, and playback are provided from a single screen. Image capture speed ranges from 50 fps up to 400 fps, with up to 100 minutes of real-time digital recording duration. **For Free Info Visit www.nasatech.com/speed**

Motorized Cartridge Spindle

Russell T. Gilman, an SKF Company, Grafton, WI, has introduced the GHS high-speed motorized cartridge spindle with an axial and radial runout of 0.0001", spring preload, and synthetic grease lubrication. The spindle also features an air seal nose end and an air-actuated power draw bar system with taper air blast cleaning. Available sizes are 60, 80, and 100 mm. **For Free Info Visit www.nasatech.com/gilman**

Digital Multimeter

The PXI-4070 FlexDMM from National Instruments, Austin, TX, is a full-featured 6-1/2 digit digital multimeter in a single-slot 3U PXI module. Features include a 1.8 MS/s isolated digitizer mode, self-calibration, and offset compensated ohms measurement. It provides 6 parts per million basic 24-hour DC voltage accuracy and a continuously variable DC reading rate from 100 S/s at 6-1/2 digits to 5 kS/s at 4-1/2 digits. **For Free Info Visit www.nasatech.com/nidmm**

Temperature Sensor Transmitter

OMEGA Engineering, Stamford, CT, offers the OS100 series mini infrared transmitter system with a remotely mounted infrared temperature sensor and a microprocessor-based signal conditioner. The sensor head is connected to the main electronics via a 6' shielded cable. Electronics are mounted in a NEMA-4-rated die-cast aluminum housing, and feature adjustable emissivity, linear voltage, current, or type K thermocouple output calibrated for the unit's 0 to 1000°F measurement range. **For Free Info Visit www.nasatech.com/omeganov**

New LITERATURE

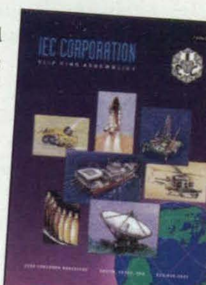
Fluid Flow Engineering

A brochure from ABZ, Chantilly, VA, describes the Design Flow Solutions software package, which implements common techniques for macroscopic fluid flow calculations. Standard and professional versions are available. The DesigNet version for network analysis, maintenance agreements, and available consulting services are also discussed. **For Free Info Visit www.nasatech.com/abz**

Physical Testing Instruments

Paul N. Gardner Co., Pompano Beach, FL, offers a 168-page catalog of physical testing instruments for the coating and related industries. Listings include adhesion, density, dispersion, film thickness, hardness, viscosity, pH and conductivity, surface profile, and optical test instruments. **For Free Info Visit www.nasatech.com/gardner**

Slip Ring Assemblies



Standard slip ring assemblies with gold plated connectors, which improve resistance against corrosion, are featured in a 12-page catalog from IEC Corp., Austin, TX. The assemblies are suitable for coil tubing reels, strain gauge, thermocouple, RTD signal transfer, shaft stress and torque measurements, and low output transducer applications. Modified and custom assemblies are also available. **For Free Info Visit www.nasatech.com/iec**

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3M Electrical Products, Austin, TX, offers a 12-page guide featuring 88 tapes plus Scotch brand 100 Cable and Wire Tie Wrap. New tapes include glass cloth, acetate cloth, composite film, filament-reinforced, polyester film, polyimide film, EMI shielding, and specialty tapes. Also highlighted are Scotch mechanical fasteners and the 3M EMI Shielding Tapes Engineering Kit, which contains nine sample rolls. **For Free Info Visit www.nasatech.com/3m**

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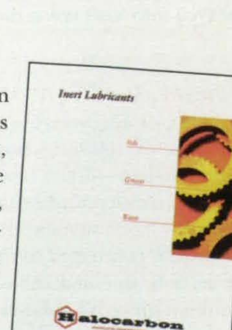

A 20-page brochure from Halocarbon Products Corp., River Edge, NJ, describes inert, nonflammable, noncorrosive oils, greases, and waxes. These products are compatible with oxygen, chlorine, fluorine, sulfuric acid, nitric acid, and other aggressive materials. Information on chemical composition, physical properties, and material compatibility is included. **For Free Info Visit www.nasatech.com/halo**

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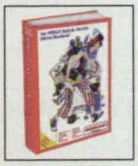

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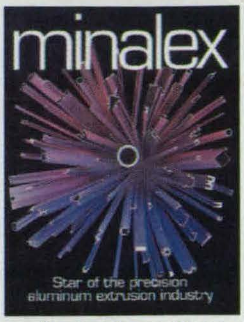

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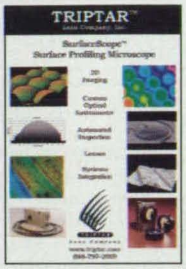

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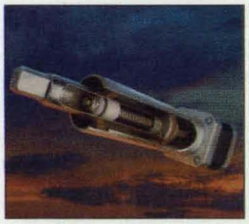

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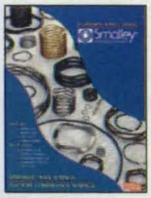

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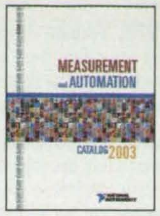

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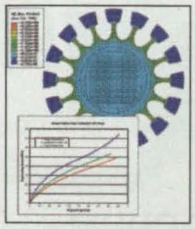

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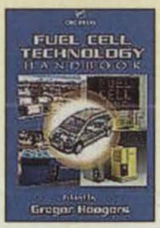

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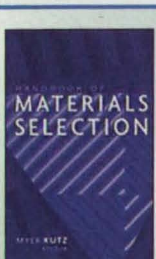

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P ❑ Power/Energy
B ❑ Bio/Medical
J ❑ Consumer Product Manufacturing
Q ❑ Industrial Machinery & Equip.
A ❑ Aerospace
G ❑ Government
D ❑ Defense
R ❑ Research Lab
U ❑ University
Z ❑ Other *(specify)*: ____________

3 **Your engineering responsibility is:** *(check one)*

A ❑ Manage Engineering Department
B ❑ Manage a Project Team
C ❑ Manage a Project
D ❑ Member of a Project Team
E ❑ Other *(specify)* ____________

4 **Your job functions are:** *(please check all that apply)*

10 ❑ Design & Development Engineering (Inc. applied R&D)
12 ❑ Testing & Quality Control
13 ❑ Manufacturing & Production
14 ❑ Engineering Management
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Write in the number of your principal job function ____________

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39 ❑ Optics/optical components
40 ❑ Fiber optics
41 ❑ Optical design software
20 ❑ Motion control/positioning equipment
30 ❑ Fluid power and fluid handling devices
31 ❑ Power transmission/motors & drives
42 ❑ Rapid prototyping and tooling
13 ❑ Metals
28 ❑ Plastics & ceramics
27 ❑ Composites
43 ❑ Coatings
80 ❑ None of the above

6 **How many engineers and scientists work at this address?** *(check one)*

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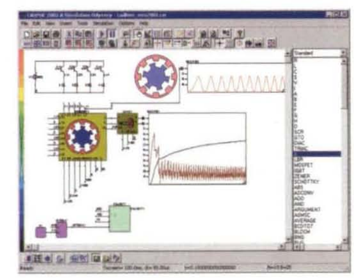

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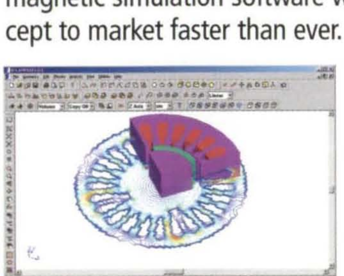

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